OPERATIVE SURGERY

UNDER THE GENERAL EDITORSHIP OF

CHARLES ROB, M C

M.CHIR., F.R.C.S.

Professor of Surgery, St Mary's Hospital, London

and

RODNEY SMITH

M.S., F.R.C.S

Surgeon, St George's Hospital, London

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CONSULTANT AND ASSOCIATE EDITORS

J CRAWFORD ADAMS, M.D F.R.C.S

ORTHOPAEDIC SURGEON ST MARY'S HOSPITAL, LONDON

R. J V BATTLE, M.B.E., M CHIR., F.R.C.S

PLASTIC SURGEON TO QUEEN ELIZABETH HOSPITAL FOR CHILDREN AND TO ST THOMAS'S HOSPITAL, LONDON

SIR STEWART DUKE-ELDER, K.C.V O., PH.D., D SC., LL.D M.D F.R.C.S

DIRECTOR OF RESEARCH, INSTITUTE OF OPHTHALMOLOGY UNIVERSITY OF LONDON OPHTHALMIC SURGEON MOORFIELDS EYE HOSPITAL, LONDON

MAXWELL ELLIS, M.D., M.S., F.R.C.S

SURGEON TO THE ROYAL NATIONAL THROAT NOSE AND EAR HOSPITAL, LONDON EAR, NOSE AND THROAT SURGEON TO THE CENTRAL MIDDLESEX HOSPITAL, LONDON

C. M. GWILLIM, M.D., F.R.C.P F.R.C.S., F.R.C.O G

OBSTETRIC SURGEON ST GEORGE'S HOSPITAL, LONDON SURGEON SAMARITAN HOSPITAL FOR WOMEN LONDON

WYLIE McKISSOCK, O.B.E., M.S., F.R.C.S

NEUROLOGICAL SURGEON NATIONAL HOSPITAL FOR NERVOUS DISEASES, QUEEN'S SQUARE, ST GEORGE'S HOSPITAL, AND HOSPITAL FOR SICK CHILDREN GREAT ORMOND STREET LONDON

ROBERT GUY PULVERTAFT, M.B B CHIR. F.R.C.S

ORTHOPAEDIC SURGEON, DERBYSHIRE ROYAL INFIRMARY SURGEON HARLOW WOOD ORTHOPAEDIC HOSPITAL

CONTRIBUTORS TO THIS VOLUME

J Crawford Adams, M.D., F R.C.S
Orthopaedic Surgeon St Mary s Hospital London

J R. Armstrong, M.D M.Ch F R.C.S
Orthopaedic Surgeon to the Metropolitan and Lambeth Hospitals Visiting Orthopaedic Surgeon to the Manor House Hospital London

M S Brett F R.C.S
Senior Registrar The Royal National Orthopaedic Hospital London

G L W Bonney M.S., F.R.C.S
Consultant Orthopaedic Surgeon to St Mary s Hospital and Paddington Green Hospital London Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls Research Assistant to the Institute of Orthopaedics London

Donal Brooks, M.A., M.B F R.C.S. (I.)
Consultant Orthopaedic Surgeon Barnet General Hospital Hertfordshire Consultant Orthopaedic Surgeon at Heritage Schools and Hospital Chailey Clinical Research Assistant Institute of Orthopaedics London

Norman Capener, F R.C.S
Consultant Orthopaedic Surgeon Princess Elizabeth Orthopaedic Hospital and Royal Devon and Exeter Hospital Exeter Mount Gold Orthopaedic Hospital Plymouth

Denis M. Dunn F R.C.S
Orthopaedic Surgeon to the Colchester Group of Hospitals

P H. Newman *D.S O., M C* F R.C.S.
Orthopaedic Surgeon to the Middlesex Hospital and the Royal National Orthopaedic Hospital London

K. I. Nissen F R.C.S
Surgeon The Royal National Orthopaedic Hospital London

H. Osmond-Clarke, C.B.E. M.B B Ch., F.R.C.S (I.) F R.C.S (Eng.)
Orthopaedic Surgeon the London Hospital Consultant Orthopaedic Surgeon, Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

Robert Roaf M.A F R.C.S (Eng.) F.R.C.S (Ed) M Ch. (Orth.) B.M B Ch., D.R.C.O G
Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry Lecturer in Orthopaedic Surgery at the University of Liverpool

Joseph A. Trueta, M.A., M.D., D Sc. F R.C S
Nuffield Professor of Orthopaedic Surgery University of Oxford

O J Vaughan-Jackson V R.D B.M., B Ch., F R.C.S
Orthopaedic Surgeon the London Hospital Consultant in Orthopaedics to the Royal Navy

E. W. Meurig Williams, O.St.J., B.Sc., M.B., B.Ch., M.R.C.S., L.R.C.P.
Consultant Orthopaedic Surgeon, Prince of Wales Orthopaedic Hospital, Cardiff, Welsh Regional Hospital Board

J. N. Wilson, Ch.M., F.R.C.S.
Consultant Surgeon, The Royal National Orthopaedic Hospital, London

H. L.-C. Wood, M.S., F.R.C.S.
Orthopaedic Surgeon, King's College Hospital, London; Orthopaedic Surgeon, The Royal Masonic Hospital

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ORTHOPAEDIC SURGERY

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BASIC SURGICAL TECHNIQUE

J. CRAWFORD ADAMS, M.D., F.R.C.S.
Orthopaedic Surgeon, St. Mary's Hospital, London

GENERAL

SPECIAL EQUIPMENT

Orthopaedic table

For most orthopaedic work the simplest of orthopaedic tables is as satisfactory as the most elaborate and expensive model obtainable. The only essential requirements are that the table be provided with a platform that may be easily lowered to leave the patient supported only upon the pelvic rest and chest piece; that it have efficient foot pieces that are rigid, yet easily adjusted for length and rotation; and that the pelvic rest be fitted with a recess underneath to accommodate an x-ray film cassette. It is an advantage if the table is adjustable for height by a hydraulic pump, but this feature is not essential.

Motor saws and drills

A motor saw is almost indispensable for cutting cortical bone grafts, and the same motor may be employed for drilling. The motor may be driven electrically or by compressed air. Most types of motor can be sterilized by autoclaving, but with some models the unsterilized motor is fitted into a boiled outer casing. Suitable precautions must be taken against sparking if an inflammable anaesthetic is used.

Hand tools for cutting or shaping bone

Osteotomes are finely tapered to a sharp cutting end without any bevel. Their main use is in dividing a bone that is relatively soft, such as cancellous bone. If a hard cortical bone is to be divided and access for the use of a saw cannot be obtained, the bone should be weakened along the proposed line of section by drilling a row of holes before the osteotome is driven in (Illustration 1).

Chisels are bevelled on one surface and flat on the other. They are more useful than osteotomes for paring the superficial surface of a bone—as in shaping the ends for an arthroplasty or preparing a flat bed for a bone graft—because the bevel allows the chisel to be held at a convenient angle to the bone (Illustration 2).

Gouges are of curved section and they are slightly bevelled like a chisel at the cutting end. They are used mainly for shaping curved surfaces, whether convex or concave.

Hand-saws are made in various patterns and sizes, but an ordinary engineer's hack-saw with expendable blades is as useful as any of the special instruments. The Gigli wire-saw is occasionally useful for dividing a bone when access for the use of a straight-bladed saw cannot be obtained.

Bone-cutting forceps are suitable for dividing small and rather soft bones. Only small "bites" should be taken when dividing a bone with this instrument: if the whole width of the bone is taken in one "bite" the bone is liable to be crushed and splintered.

Nibbling forceps or rongeurs are useful for trimming small fragments from the bone surface or for cutting away bony projections such as the vertebral laminae and spinous processes.

THE NON-TOUCH TECHNIQUE

Many orthopaedic surgeons follow more or less completely the principles of the non-touch technique developed by Lane (1914) and advocated by Fairbank (1942) and others. The object of this specialized operative technique is to reduce to a minimum the risk of bacterial contamination of the wound from the hands of the surgeon or his

assistants. It is argued that bone, once infected, is able much less effectively than most soft tissues to overcome the infection because its rigid structure does not allow the rapid swelling that forms part of the inflammatory reaction. Infection after operations upon bone or joint is indeed a dreaded complication, often devastating in its effects and it behoves every surgeon who undertakes such operations to take every precaution that he can to avoid contamination of the wound. The use of the non-touch technique is only one contribution to this end bone surgery cannot be freed completely from the risk of infection until other refinements, such as air-conditioning with bacteria-free filtered air are made available.

Each surgeon must decide for himself whether the non-touch technique is worth-while. The writer is convinced that it well justifies the very little trouble that it entails. He has many times watched nurses and assistants—and sometimes even experienced surgeons—contaminate their hands unwittingly while gowning-up or while draping the patient a rigid non-touch technique is the only sure safeguard against infection from this cause.

Principles of the non-touch technique

Those who use the non-touch technique assume that the gloved fingers are potentially contaminated, and they therefore follow the principle that neither the fingers, nor anything that has been touched by the fingers, should ordinarily be allowed to enter the wound. If at a particular stage of the operation it becomes essential to palpate the tissues through the wound a fresh over-size glove is put on over the normal glove for the purpose (this is safer than changing the gloves) Swabs, packs, ligatures and suture materials are held only with forceps, never by the fingers. Only the point of each instrument is allowed to enter the wound, and that part of the instrument must never be touched by hand.

Details of technique

A rectangular rather than a kidney-shaped instrument trolley should be used. The cloth draping the top of the trolley is demarcated clearly into three longitudinal strips, of about equal width. For convenience the central strip may be coloured red, the outer strips being white or green. In laying out the trolley with instruments the handle of each instrument is placed over one of the outer strips and the point over the central strip (Illustration 8) The outer strips of the trolley cover may be touched by hand when instruments are taken from the trolley or replaced upon it, but the central strip is "sacred and must not be touched by the hand or by any object that has been handled.

After use each instrument is returned immediately to its proper position on the instrument trolley and no instrument must be left lying about on the operating table or on the patient s body

Once the theatre team has become familiar with the non-touch technique its use becomes second nature. It makes for neatness and adds practically nothing to the operating time.

TOURNIQUETS

Tourniquets are used almost as a routine in operations upon the limbs, and in most cases there can be no objection to their use provided the risks are understood and proper safeguards observed.

Types of tourniquet

The old-fashioned tubular rubber tourniquet should never be used. It beds deeply into the tissues like a cord, and may cause serious damage to nerves or arteries.

The Esmarch rubber bandage is satisfactory if used correctly but it can be dangerous if applied injudiciously The pressure required is seldom more than 260 millimetres of mercury even for the lower limb This pressure can be obtained easily with three, or at most four turns of the bandage. If the whole bandage is applied at full stretch an enormous constricting force is built up and it may cause serious injury (*See also* Volume 1 Part I, page 89)

The pneumatic tourniquet is by far the safest type and it is to be hoped that it will supersede all other types for routine use. For the upper limb the ordinary sphygmomanometer cuff inflated to a pressure of 200 millimetres of mercury is adequate. For the lower limb a larger and stronger cuff is required, and the pressure should usually be maintained at about 260 millimetres of mercury (*See also* Volume 1 Part I, page 88)

Technique of application

For operations upon the upper limb the tourniquet should be applied high in the upper arm For operations upon the lower limb it should be placed high on the thigh or for foot or toe operations, round the middle of the calf The limb distal to the tourniquet should be exsanguinated by a rubber bandage before the tourniquet is inflated.

Safe duration of tourniquet constriction

Hard-and fast rules cannot be laid down because the safe period of tourniquet constriction depends upon the pressure used and upon the bulk of the patient s limb as well as upon the time. In the first three hours, the main danger is from mechanical pressure upon the nerve trunks rather than from ischaemia. The thinner the limb the greater is the risk of the nerves being trapped between tourniquet and bone. Indeed in a very emaciated patient whose limbs consist of little more than skin and bone it is unwise to apply a tourniquet at all to the arm. Likewise in a child with thin arms the use of a tourniquet should preferably be avoided. On the other hand, in patients with reasonably bulky limbs a tourniquet may safely be left in position for one to one and a half hours in the case of the upper limb and for two hours in the lower limb provided excessive pressure is not used. These times apply only to constriction with pneumatic cuffs they should be halved if an Esmarch tourniquet is used.

Ensuring removal of the tourniquet

A strict routine should be adopted to ensure that a tourniquet is not inadvertently left in position The responsibility is always the surgeon s, no matter who has applied the tourniquet under his direction. One useful safeguard is to insist that the end of the tourniquet be tied to the operating table As additional safeguards, the theatre sister should check the number of tourniquets in the theatre after each operating session and it should be the duty of the ward sister to examine each patient on his return from the operating theatre specifically to make sure that a tourniquet has not been left on and that the circulation in the limb is satisfactory

USE OF DIATHERMY

The diathermy should be used sparingly in orthopaedic technique Admittedly it is a great time saver and the surgeon need not deny himself its advantages, especially in operations upon the shoulder region hip or spine where troublesome oozing is often encountered. But if it is used to excess, especially for cutting it leaves a considerable mass of charred tissue which favours the growth of pyogenic bacteria. Most small "bleeders will seal themselves if left clamped with a haemostat for several minutes, and it is usually found that the number of vessels that actually require coagulating is small.

PLASTER TECHNIQUE

Plaster of paris is hemihydrated calcium sulphate. With the addition of water it undergoes an exothermic reaction to become hydrated calcium sulphate, which sets into a solid mass. The plaster is enmeshed in muslin, which increases its strength and facilitates its application.

Technique of application

An unpadded plaster should not be applied directly to the skin It is much more comfortable if it is lined by a single layer of cellulose wool or a tube of stockingette.

A padded plaster should be applied over several layers of surgical cotton wool. When considerable swelling is expected after an operation upon a limb the plaster should always be padded copiously in this way but the use of a padded plaster does not absolve the surgeon from the obligation to keep a close watch on the peripheral circulation during the first 48 hours after operation.

Most proprietary plaster bandages are quick-setting and should be used with cold water Home made" plaster bandages usually set more slowly and they are best used with warm water which speeds the setting process.

After being soaked only just long enough to allow all the air bubbles to escape, the bandages are rolled on to the limb without tension care being taken to hold the bandage out to its full width at each turn. After each bandage has

been applied the plaster is moulded to the bony contours so that it fits snugly at every point. When the first few layers have been applied the plaster may be reinforced by "slabs" or strips made with about twelve thicknesses of plaster bandage. These "slabs" are held in place by further turns of rolled plaster bandage.

Drying

To dry the plaster it should be exposed to the open air for a few hours. Artificial methods of drying, as by a hot air cradle, are unnecessary and they are not recommended.

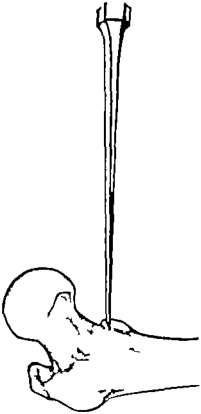
Walking heels

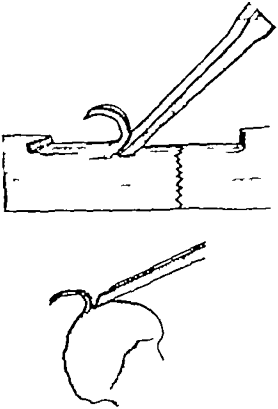
Iron walking heels of the Bohler type are not recommended because they encourage an unnatural twisting gait moreover the metal hinders radiography through the plaster and makes removal of the plaster more difficult Heels or rockers made from solid plaster rubber or wood are preferred. A water-proof canvas over-boot should be worn over the plaster

OPERATIVE TECHNIQUE

Division of a femur

1 A femur is shown being divided with a thin osteotome after the bone has been weakened by multiple drill holes.

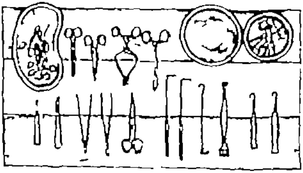




2

Taking a shaving of bone

The use of a chisel in shaving bone from a surface is illustrated. In the preparation of a bed for an onlay graft the bevel of the chisel is placed downwards. The other illustration shows the method of shaping the femoral head for an arthroplasty



3

Trolley layout for no-touch technique

The layout of the trolley cover and instruments for the non-touch technique is shown here. The points of the instruments lie on the central strip which must never be touched by hand or by anything that has been handled.

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INERT MATERIALS TECHNIQUES OF INTERNAL FIXATION FOR FRACTURES

J Crawford Adams, M.D., F.R.C.S.
Orthopaedic Surgeon St Mary's Hospital London

PRE-OPERATIVE

Inert materials

Internal appliances of various kinds are used widely in orthopaedic surgery Much research has been applied in evolving materials that neither corrode nor cause a harmful reaction in the living tissues in which they are embedded. The materials that are in common use fall into two main groups—metals and plastics.

Metals

Metals that were used in the earlier days of bone surgery such as silver and plated steel, have had to be abandoned because they were found to corrode and eventually to disintegrate in the tissues, at the same time causing a chronic inflammatory reaction. In recent years research by metallurgists has led to the development of a number of metals or alloys that are resistant to corrosion and produce little or no reaction in the host tissues. These products include (1) special steels (2) chrome-cobalt alloys and (3) certain metallic elements.

Special steels—When iron is implanted in the tissues the protective film of iron oxide is destroyed, and the metal passes into solution as cations (Scales, 1956) Rapid corrosion may thus occur The rate of corrosion is increased if another metal of different electrical potential lies close to the iron implant, for a battery is set up between the two dissimilar metals. (Compare the dissolving of a zinc electrode in a voltaic cell.) The addition of chromium to a ferrous alloy gives protection against corrosion because a stable oxide of chromium is formed upon the surface and the addition of nickel and molybdenum further increases the resistance to corrosion. A steel containing 18 per cent chromium, 8 per cent nickel, and 2 per cent molybdenum has been found to be almost immune from corrosion in the tissues provided it is not used in conjunction with another metal of different electrical potential, and provided its polished oxide-coated surface is not damaged by scratches or abrasions. This steel, known as 18/8 SMo steel, has been widely used for many of the internal appliances used in orthopaedic surgery

Chrome-cobalt alloys—Alloys of chromium and cobalt are more resistant than any of the ferrous alloys to corrosion in the tissues, and their use for internal appliances is being increasingly favoured. These alloys are difficult to machine or drill, and most appliances made from them must be cast. Hitherto such appliances have been manufactured almost exclusively by the Austenal Laboratories in America, who have given the trade name Vitallium to the alloy that they use

Metallic elements—It is possible that certain metallic elements such as tantalum, zirconium and titanium may prove suitable for the manufacture of internal appliances, but further research is needed before their place in surgery can be assessed.

Plastics

Several of the modern plastics have been found to be almost totally inert in the tissues. Each has distinctive physical properties that render it more or less suitable for a particular purpose. But an assessment of the definitive place of plastics in orthopaedic surgery must await further experience and research.

Nylon with its great flexibility and resilience is used mainly as a suture material, either as a single strand or as a thread braided from several fine strands. It may be used as an internal unabsorbable suture or for skin closure. Its advantages lie in its strength, easy sterilization by boiling and its uniform thickness. A disadvantage especially of nylon used as a single strand is that the knot is apt to slip

Methyl methacrylate (Perspex) is harder than nylon and will take a high polish. It has been used extensively for the construction of internal prostheses such as artificial femoral heads used in replacement arthroplasty It is doubtful however whether it will stand up to prolonged use for many instances have been recorded of such prostheses breaking or wearing away on the surface

Polythene much used in general surgery in the form of flexible tubes, has a limited application in orthopaedics. It has been used for the manufacture of internal prostheses, but it is too soft to serve satisfactorily as part of a movable joint.

Indications

Internal fixation is required when the fragments cannot be held in an acceptable position or sufficiently immobile by closed methods. It is recommended as a routine after operative reduction of a fracture, and it may be used to allow early activity of the injured part, especially in elderly patients.

Contra-indications

In open fractures internal fixation increases the risk of bone infection and should be avoided altogether or deferred until the wound has healed.

Special equipment

An adequate range of bone-holding forceps, bone clamps, rongeurs, bone cutters, chisels, osteotomes and gouges should be available. Special instruments are required for certain techniques, such as medullary nailing When the bone is to be drilled a power drill should be chosen in preference to a hand drill not only does a motor drill make the work easier it also reduces the risk of drills breaking off in the bone.

Pre-operative preparation

Because of the serious consequences of infection of a bone after operation it is wise, whenever practicable, to admit the patient to hospital at least 48 hours before the operation, to allow adequate cleansing and preparation of the skin.

Anaesthesia

General anaesthesia is recommended as a routine but in special circumstances spinal anaesthesia for the lower limb or regional anaesthesia for the upper limb may be used.

Use of tourniquet

The use of a tourniquet is recommended when it is safe and practicable. The technique and precautions to be observed in the use of tourniquets are described in the Chapter on Basic Surgical Technique (page 8) and in Volume 1 Part I, page 87

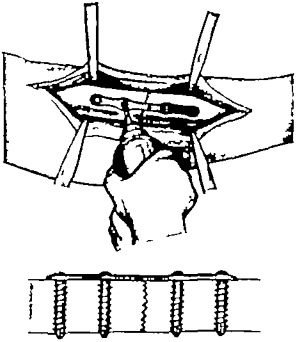
THE OPERATIONS

Methods of fixation

According to the site and nature of the fracture one of eight methods of fixation may be used (1) metal plate (2) onlay bone graft (3) oblique transfixion screws (4) axial screw (5) circumferential wires (6) intramedullary nail (7) wire sutures through bone and (8) sutures through soft tissue.

Fixation by metal plate

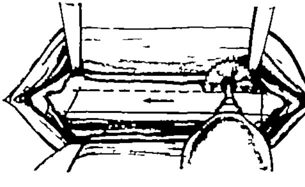
1 After a suitable length of the bone has been exposed subperiosteally above and below the fracture the broken surfaces are cleared of blood clot and fibrin and manipulated into perfect apposition and alignment with the aid of bone-holding forceps and bone levers. A plate of suitable dimensions, preferably made from Vitallium, is placed in position bridging the fracture on a submuscular surface of the bone. The plate is clamped to each fragment by suitable forceps or by a bone clamp. Holes are drilled with a motor drill, their diameter equal to the root diameter of the screws that are to be used. The correct length of screw is determined by a depth gauge and the appropriate screws (of the same metal as the plate) are driven home firmly but not too forcibly lest the thread in the bone be stripped.



Fixation by onlay bone graft

2 The technique is the same as for fixation by a metal plate except that a cortical slab graft, usually obtained from the tibia, is used instead of the metal plate.

The bone graft should usually be obtained from the tibia (see Chapter on Bone Grafting Techniques, page 1[illegible]) In the case of a bone-grafting operation for a fracture of the tibial shaft the graft may usually be obtained from another part of the same bone, rather than from the sound tibia. In some cases of ununited fracture of the radius with a fracture of the ulna near its lower end the distal fragment of the ulna may be excised and used as a graft for the radius.

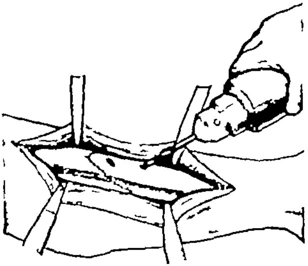


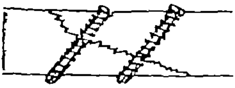
Fixation by oblique transfixion screws

3 This method is applicable only to oblique or spiral fractures without comminution.

Only a *short incision* is required, giving just enough exposure to allow the fracture surfaces to be cleared and reduced accurately

While the position of the fragments is maintained by a bone clamp or stout bone-holding forceps two holes are drilled obliquely across the fracture line. The holes should be at least half an inch and preferably three-quarters of an inch apart. *Care should be taken to ensure* that the drill holes are in sound bone, well away from the fractured edge. The drill holes should be equal in diameter to the root diameter of the screws to be inserted, but it is advantageous to enlarge the proximal part of each hole—that is, the part through the more superficial fragment—so that when the screws are driven home the fragments will be forced firmly together

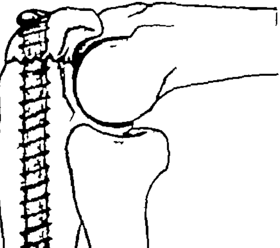




Fixation by axial screws

4 This technique is applicable to fractures of the olecranon process of the ulna, to certain fractures of the patella, and to fractures of the medial or lateral malleolus.

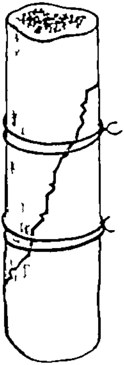
After exposure of the fracture site the bone surfaces are cleared, approximated, and fixed temporarily with a suitable bone clamp such as that devised by Charnley A drill equal in diameter to the root diameter of the screw is entered at the tip of the smaller fragment and passed axially into the main fragment to a depth that will allow an adequate grip of the screw—usually at least two inches. The hole in the smaller fragment is drilled out to the outside diameter of the screw A long screw preferably with a coarse thread, is driven home firmly *with care not to strip the thread in the* main bone fragment by excessive force.



Fixation by circumferential wiring

5 This alternative method is applicable only to long oblique or spiral fractures of the long bones. It is seldom employed because it is no more effective than fixation by transfixion screws and entails more extensive stripping of the bone ends.

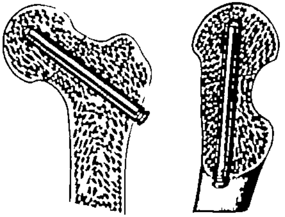
The fracture surfaces are cleared, reduced, and held in position. By means of a sharply curved bone lever the periosteum is separated from the bone circumferentially for a distance of about two inches at the level of the fracture. Stainless steel wire, of about 24 gauge for the tibia and a little stronger for the femur is threaded round the bone if necessary with the aid of a curved slotted probe or an aneurysm needle. A single wire may suffice for a small bone such as the radius, but usually two or even three wires should be passed, about an inch apart. Each should make a double turn round the bone and the ends are then drawn tightly and twisted together



Fixation by intramedullary nail

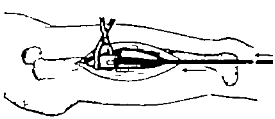
Nailing of fracture of neck of femur

6 This technique is applicable to fractures of the shaft of the femur the humerus, and the ulna, for in each of these bones the nail can be inserted at the proximal end without encroaching upon the articular surface. It is used routinely for fractures of the neck of the femur It may also be adapted to other bones such as the tibia, the clavicle and the metacarpal bones. Before nailing of a long bone the diameter of the medullary canal should be measured radiographically to allow a nail of the correct thickness to be selected.



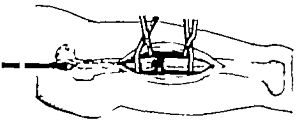
Nailing of fracture of the shaft of the femur

Exposure of fracture and insertion of nail in proximal fragment—The site of fracture is exposed sufficiently to allow the bone ends to be cleared and freshened. A nail of the correct length and diameter is inserted, blunt end first, into the fractured end of the proximal fragment and driven proximally until its blunt end can be felt to have emerged through the proximal end of the bone



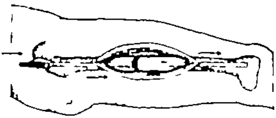
Exposure of nail at proximal end of bone

7 A short second incision is made over the upper end of the nail to allow it to project through the skin Further blows on the sharp end of the nail drive it upwards until only about half an inch of its point is left projecting at the fracture site.



Reduction of fracture and impulsion of nail into distal fragment

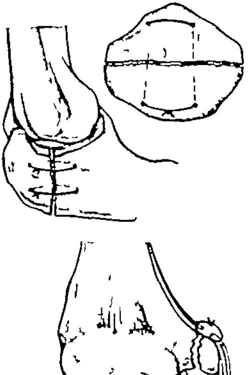
8 Strong traction is applied to the limb by an assistant while the surgeon with bone-holding forceps, manipulates the bone ends into perfect apposition and alignment, the short projecting point of the nail being made to engage in the medulla of the distal fragment. The nail is now driven downwards into the distal fragment by blows upon the projecting upper end. Radiographs are taken to make sure that it is following the desired course and to check that its length is correct. As a rule the nail should be driven well down the shaft, to within about an inch of the lower articular surface.



Fixation by wire sutures through bone

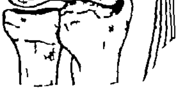
9 The bone fragments are coapted accurately and held in position. A hole of about one-eighth of an inch in diameter is drilled transversely through each fragment. A wire suture of suitable gauge is passed in such a way that when it is tightened the bone fragments are drawn firmly together

This method is applicable mainly to fractures of the olecranon and of the patella. It is less reliable than fixation by screws in maintaining perfect apposition.



Fixation by sutures through soft tissue

10 When perfect apposition of the fragments is not essential satisfactory fixation can often be secured by sutures passed through the soft tissues close to the bone fragments.



POST-OPERATIVE CARE

Immobilization and support of limb

After internal fixation of a fracture by a bone graft, or by screws or wires, it is advisable to protect the limb from external forces by immobilization in plaster. External support is usually unnecessary after rigid internal fixation by an intramedullary nail (as used, for example, for fractures of the neck or shaft of the femur) or by a combination of nail and plate (as for trochanteric fractures of the femur). Immobilization in plaster is generally advisable after fixation by metal plate and screws, but if the plate is strong and rigid external support may sometimes be dispensed with.

When a plaster is used it should be changed 2 or 3 weeks after the operation, and the skin sutures may be removed at the same time.

Antibiotic cover

If there has been previous infection at or near the site of fracture adequate antibiotic cover should be given during the first week after operation.

Weight-bearing in fractures of lower limbs

In fractures of the lower limbs treated by internal fixation walking may usually be allowed, with suitable precautions, before the fracture is fully consolidated. The exact time at which it will be safe to allow weight-bearing varies with the site and nature of the fracture, and hard-and-fast rules cannot be laid down. In the case of major fractures of the tibia fixed by plates, screws or bone grafts walking in plaster is usually permitted 4–6 weeks after the operation. After rigid fixation of femoral fractures by an intramedullary nail or by a nail-plate walking may often be encouraged considerably earlier though many surgeons are cautious about allowing weight-bearing after fractures of the femoral neck and prohibit it for 12 weeks or more despite firm fixation by a nail.

[*The illustrations for this Chapter on Inert Materials: Techniques of Internal Fixation for Fractures were drawn by Miss Christine Lamb.*]

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BONE GRAFTING TECHNIQUES

J Crawford Adams, M.D., F.R.C.S
Orthopaedic Surgeon St Mary's Hospital London

PRE-OPERATIVE

Indications

Bone grafts are indicated (1) for fractures complicated by delayed union or non-union (2) to aid the establishment of arthrodesis of a joint and (3) to obliterate a bone cavity or defect

Contra-indications

Bone grafting should not be attempted in the presence of active infection. A bone cavity in chronic osteomyelitis should be un-roofed, gouged down to healthy bone and lined by split skin grafts at a preliminary operation before the final obliteration of the cavity by bone grafts is considered.

Special equipment

A motor-driven saw is almost indispensable for cutting a graft from hard cortical bone such as the shaft of the tibia. The same motor may be used to drill holes in cortical grafts and recipient bone to allow fixation of the graft by screws. A tourniquet is not required for taking a bone graft and its use is not recommended.

Types of graft

Bone grafts are used in two forms—cortical grafts and cancellous grafts. Each has its special advantages and uses.

Cortical bone grafts

Cortical bone is to be preferred when the graft is required to aid fixation as well as to promote the formation of bone. Cortical grafts are therefore recommended for most cases of ununited fracture, and generally also for promoting extra articular arthrodesis. Such grafts are usually cut from the tibia, but other sites, such as the ulna or fibula, may be chosen when appropriate. Fixation to the host bone is usually secured by screws, but alternative techniques such as inlaying or over-suturing may be preferred in certain circumstances.

Cancellous bone grafts

Grafts of cancellous bone have their main application in obliterating bone cavities (as after the excision of a bone cyst or tumour) and in filling spaces between and around the bone ends in arthrodesis. For these purposes the bone is usually cut into small shavings or chips, but in some circumstances solid blocks of bone may be preferred They may be used in conjunction with cortical bone grafts or with metallic internal fixation.

Cancellous grafts are usually cut from the wing of the ilium, but a small supply of loose-textured spongy bone may be obtained from other sites, such as the upper end of the tibia or the lower end of the radius.

The use of stored bone

In most bone grafting operations the grafts are obtained from the patient himself (autogenous grafts) and this practice is to be recommended whenever practicable because the results are more reliable than they are when stored bone is used.

When a suitable supply of autogenous bone is not available (as in children requiring massive grafts) or when it is desired to spare the patient the inconvenience of a separate procedure for graft-taking stored human (homogenous) bone grafts may be used. Such grafts may be stored under strictly aseptic conditions either in the frozen state or in merthiolate solution or the grafts may be stored dry and boiled before use

THE OPERATIONS

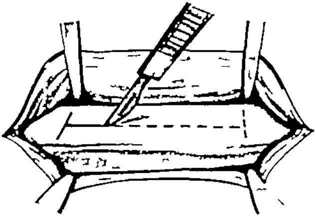
TECHNIQUE OF CUTTING A CORTICAL BONE GRAFT FROM THE TIBIA

The incision

1 The main part of the incision is placed vertically over the muscles of the antero-lateral compartment of the leg about $\frac{3}{4}$ inch from the crest of the tibia. Its extremities curve medially to end over the subcutaneous surface of the tibia. It is a mistake to place the whole incision over the bone because the scar will become adherent and is much more likely to cause subsequent trouble than a scar that lies over the soft tissues. The length of the incision will depend upon the size of the graft required.

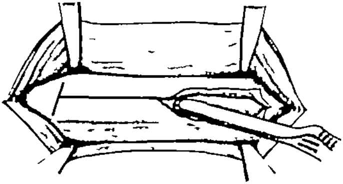
Skin flap

2 The broad-based skin flap outlined by the incision is raised with the subcutaneous tissue from the deep fascia covering the antero-lateral compartment of the leg and, farther medially from the periosteum covering the subcutaneous surface of the tibia.



Incision and stripping of periosteum

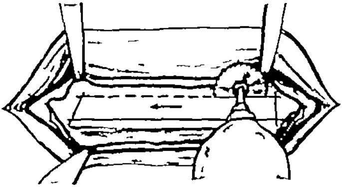
3 The skin flap being retracted medially a vertical incision is made through the periosteum over the middle of the subcutaneous surface of the tibia. At each end of this incision transverse cuts are made through the periosteum across the full width of the tibia. With a sharp periosteal elevator the periosteum is stripped from the bone over as wide an area as necessary. The periosteal flaps are held out of the way by bone spikes passed subperiosteally round the tibial shaft at each side.



Cutting the graft

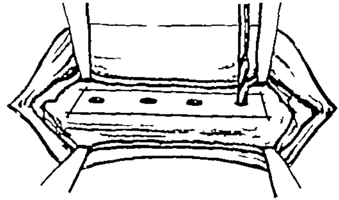
4 The outlines of the projected graft are marked lightly upon the bone after measuring with a ruler. All loose swabs and packs must be removed from the area of operation lest they get caught in the saw blade. The motor saw is gripped rigidly in both hands and the blade is entered into the bone while rotating. With the usual type of motor saw, the shaft of which rotates clockwise (as seen from the operator's end), the bone cut should always be made from right to left. The blade thus bites its way deeply into the bone as the saw is moved along, whereas if the cut is made in the reverse direction the blade will run out of the bone.

When the two longitudinal cuts have been made (a twin-bladed saw may be used to ensure parallel cuts if desired) the graft is detached by making transverse cuts at each end. When these transverse cuts are made with the saw particular care must be taken to grip the motor very securely to prevent its running away and becoming entangled with the towels. In many cases the corners of the graft will have to be freed with a thin osteotome or chisel before the graft can be levered out of its bed.



Drilling the graft for screw fixation

5 If the graft is to be onlayed and fixed with screws it is often convenient to drill the holes in the graft while it is still supported and held steady in its bed. A drill equal in diameter to the outside diameter of the screws should be used, to allow a sliding fit of the screws.

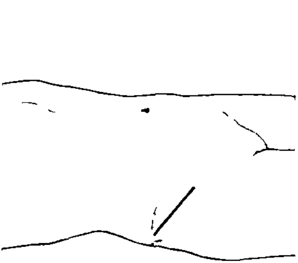


TECHNIQUE OF CUTTING CANCELLOUS GRAFTS FROM THE ILIUM

Position of patient the incision

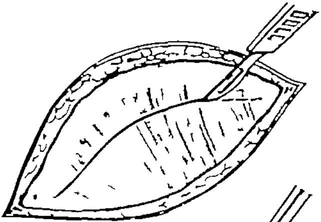
6 The patient lies recumbent upon his back, with the side to be operated upon projected slightly forwards by means of a sandbag under the buttock

The incision begins at the anterior superior iliac spine and extends backwards in a straight line to a point on the crest of the ilium about 2 inches in front of the posterior superior spine The incision thus forms a chord to the bow formed by the anterior two-thirds of the crest of the ilium. The skin edges are mobilized for a short distance and retracted to expose the crest of the ilium and the fascia covering the tensor fasciae latae and gluteus medius muscles.



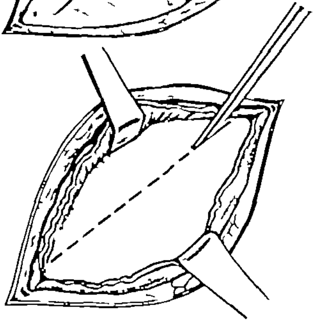
Additional exposure of the bone

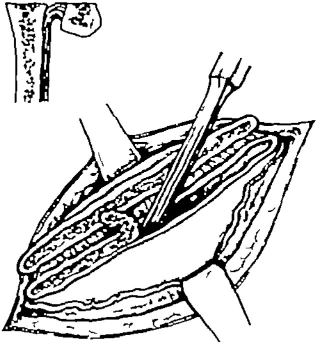
7 The gluteus medius muscle with its covering fascia is divided by a curved incision which runs parallel with the crest of the ilium and about [illegible] inch below it. This incision cuts straight down to the bone of the outer table of the wing of the ilium. With a periosteal elevator the muscle is stripped away from the bone downwards for [illegible] inch below the line of incision and upwards to the crest of the ilium



Osteotomy and rotation of iliac crest as a flap

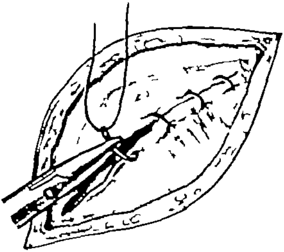
8 With a thin osteotome the wing of the ilium is divided in a straight line extending from a point near the anterior superior spine to a point on the iliac crest about 2 inches in front of the posterior superior spine—that is, in the line of the skin incision. This leaves the iliac crest attached only by the fibres of the iliacus muscle lying upon the inner aspect of the bone. These fibres form a hinge about which the iliac crest may be rotated inwards to expose the cut surfaces of the bone





Removal of cancellous bone fragments

9 The cancellous shavings are best taken with a narrow hand gouge thrust vertically into the wing of the ilium between the outer and the inner table. In this way the bone can be scooped out like cheese. The ilium may thus be excavated to a considerable depth, yielding quite a large quantity of chips. When the main part of the bone has been exhausted additional fragments may be obtained from the "lid" or crest of the ilium by scooping the cut surface. If the bone is required as a block rather than in the form of chips it may be cut easily from the wing of the ilium, in the shape required, with a thin osteotome.



Closure

10 The hinged "lid" formed by the crest of the ilium is turned back into place and held by catgut sutures through the muscle. The skin is closed without drainage.

[The illustrations for this Chapter on Bone Grafting Techniques were drawn by Miss Christine Lamb.]

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ACUTE OSTEOMYELITIS

JOSEPH A. TRUETA, M.A., M.D., D.Sc., F.R.C.S.
Nuffield Professor of Orthopaedic Surgery University of Oxford

PRE-OPERATIVE

Indications

The subperiosteal abscess must be evacuated as soon as possible preferably by incision rather than aspiration. If acute local tenderness persists after 24 hours antibiotic treatment, operation is indicated. In most cases antibiotic treatment is started too late (2–3 days after the onset) to control the infection without surgery Pus begins to collect subperiosteally and permanent bone changes will result unless early evacuation is resorted to As a rule cases whose admission has been delayed for more than 48 hours after onset of infection, will need operation.

Pre-operative treatment

After admission a blood culture is taken and if organisms are present their sensitivity to antibiotics is tested. Penicillin 250 000 units every 6 hours is injected intramuscularly and Sulphatriad is given by mouth, in accordance with the patient's age. When the organism is resistant to penicillin, an alternative antibiotic is given. The leg is immobilized and elevated on either a Thomas or a Braun's splint. Intravenous fluid therapy or blood transfusion may be necessary

Twenty four hours after admission the patient is re-examined by the same surgeon and progress of the general and local condition is noted.

Unless there is a marked decrease in symptoms, and swelling and tenderness have mostly disappeared, the patient is prepared for operation.

Anaesthesia

General anaesthesia is used. The operation usually lasts about 15 minutes or less.

Use of tourniquet

Whenever possible a tourniquet is used to give a bloodless operative field.

PATHOLOGY

1 The infection caused by the *Staphylococcus pyogenes* is most commonly carried through the nutrient artery into the metaphysis of the long bones or more exceptionally into the short bones.

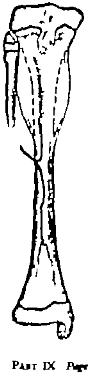
Intra-osseous infection

2 The intra-osseous infection, if left to its normal evolution, produces a widespread area of obstruction of the branches of the nutrient artery

Formation of pus

3 Pus is formed rapidly and collects underneath the periosteum, raising it from the cortex. The outer third of the cortex is thus deprived of its blood supply as the inner two-thirds have already been made ischaemic by the obstruction of the nutrient artery a large cortical sequestrum is formed. At the same time the detached periosteum produces the involucrum.

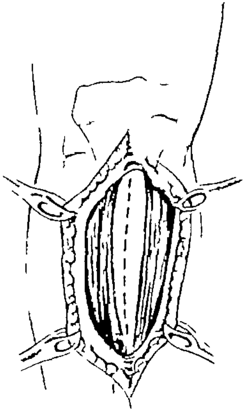
Chronic osteomyelitis becomes established in the absence of preventive treatment.

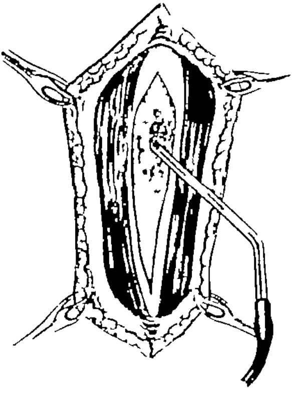


THE OPERATION

Incision

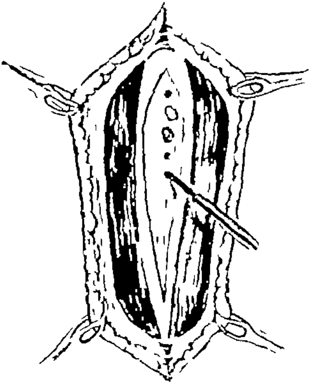
4 For the description of the operation it is supposed that the osteomyelitis is localized in the upper metaphysis of the tibia. An anterior incision is made from just above the tibial tubercle to about the middle of the leg. The periosteum is exposed and incised longitudinally without detaching it from the surrounding soft tissues or stripping it farther from the cortex than has already been done by the collecting pus.





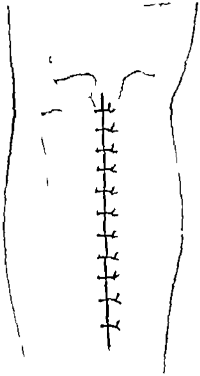
Evacuation of abscess

5 The periosteum having been incised the escaping pus may be aspirated or mopped away with a dry absorbent swab



Reduction of intra-osseous tension

6 A pneumatic drill is used to make several perforations, spaced at ½-inch intervals, through the cortex. Pus may be seen exuding from these. The tourniquet is then released to allow a flushing out of the pus from within the medullary cavity.



Closure of wound

7 Haemostasis having been secured 250 000 units of penicillin powder are sprinkled into the wound. The skin edges are brought together and the wound closed completely. No drainage is established as it is unlikely that further pus will collect once the operation has been performed.

A calico dressing is applied, and the limb immobilized and elevated. It is left immobilized for at least five days.

POST-OPERATIVE CARE

The leg is immobilized and elevated and the antibiotic treatment continued for 3 weeks or more. On the fifth day the dressing is removed and the wound inspected. If any haematoma is formed it is aspirated. The stitches are removed on the twelfth day. Wound healing, temperature, erythrocyte sedimentation rate and extent of bone damage in the radiographs will determine the time for discontinuing antibiotic treatment (usually it is unnecessary to continue for more than 3 weeks).

Immobilization

The patient is then allowed to get up but the affected limb must be immobilized in a plaster to prevent pathological fracture which may occur when the periosteum has been prevented from producing an involucrum. Total recovery does not usually take more than 3 months from the onset.

Complications

Persistent sinus is usually due either to insufficient or inappropriate antibiotic treatment or to the operation (this is the most common cause) if it is performed too late and bone necrosis is already extensive. In these cases antibiotic treatment should be continued for very much longer and if sequestra are detected in the radiographs they must be removed as soon as possible and the wound closed without drainage.

[*The illustrations for this Chapter on Acute Osteomyelitis were drawn by Miss M. C. McLarty.*]

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GROWTH DISTURBANCES
EQUALIZATION OF LOWER LIMBS

JOSEPH A. TRUETA M.A., M.D., D.Sc., F.R.C.S.
Nuffield Professor of Orthopaedic Surgery University of Oxford

DURING THE GROWTH PERIOD

Radiographs are taken of both lower limbs on a single plate placing the femora and tibiae with the tube well centred and as far distant as possible from the plate. Measurement of both extremities is done on the plate and further radiographs are taken 3 months later and again at 6 months. The rate of growth disparity is established by comparing the growth of each extremity during the 6 months of observation.

Indications

An operation to stimulate or to decrease growth is indicated when the disparity is still increasing or in some cases when the difference in length is already so marked that it would constitute a severe permanent disability (2 inches or more). It is better to perform the operation for growth stimulation of the shorter limbs or arrest of growth of the longer before the age of 12 years.

CORRECTION OF INEQUALITY IN THE ADULT

SHORTENING OF THE NORMAL LEG

There are two main procedures shortening of the longer leg or lengthening of the shorter Shortening of the longer leg is the safer of the two methods and it must be recommended whenever possible.

LENGTHENING OF SHORT LEG

Indications

Lengthening is more likely to be indicated in women than men for cosmetic reasons. The main candidates for this operation are patients suffering from the consequences of paralytic poliomyelitis. The femur is the bone of choice, but the tibia and fibula are on occasion also lengthened, particularly when the main shortening is located in this segment of the lower limb.

Purpose of operation

The aim of this operation is to obtain the lengthening required provided that this does not go beyond the extent where traction of the main arteries and nerves of the extremity would endanger the circulation From 2 to 3 inches, depending on the height of the patient, is the length that can be gained without great risk. To attempt greater lengthening is to expose the patient to serious and sometimes to disastrous consequences.

THE OPERATIONS

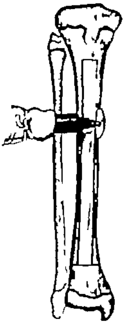
DURING THE GROWTH PERIOD

Stimulation of Growth

Both tibia and femur can be stimulated by the same type of procedure. A tourniquet is used in either case. The operation on the tibia will be described.

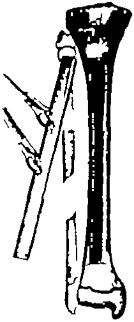
Removal of segment of tibial shaft

1 An anterior incision extending from the proximal to the distal metaphysis is made. The periosteum of the whole of the shaft is elevated and retractors are placed round the tibial shaft to allow a segment of the cortical bone of the shaft of about a quarter of the width of the perimeter of the tibia and extending about 1 inch or slightly more from the two epiphysial plates to be removed. An electric circular saw is used.



Excision of segment of fibula

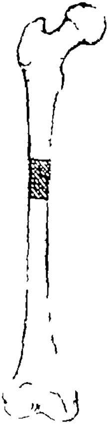
2 This segment is then detached from the tibia and submerged in boiling water for 5 minutes in order to kill the osteocytes with the purpose of delaying its reabsorption. In the meantime a segment of about 2 inches of the middle third of the fibula with its periosteum is excised.

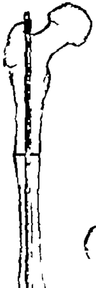


Introduction of tibial segment into marrow cavity

3 The bony marrow cavity of the tibia is curetted out, particular care being taken to destroy the nutrient artery in its intra-cortical canal. The boiled bone is introduced into the bony marrow cavity with the superficial part of the cortex rotated towards the bony marrow cavity

The periosteum is sutured with interrupted catgut and the skin with fine silk. A well padded above knee plaster is applied.





INEQUALITY IN THE ADULT

SHORTENING OF THE NORMAL LEG

Resection

4 The femur is the bone of choice and the best procedure is to remove the appropriate amount of bone from the shaft at about the junction of the uppermost and middle thirds.

Stabilization with Kuntscher nail

5 The two fragments are then stabilized by the use of a Kuntscher nail entered proximally and driven downwards across the site of the osteotomy It is advisable to use a nail of the maximum size compatible with that of the bony marrow cavity

When the shortening is of more than 4 inches (about 10 cm.) difficulties may be encountered in suturing the aponeurosis because the muscles tend to bulge. The deep tissues are sutured with catgut and the skin with silk.

LENGTHENING OF THE SHORT LEG

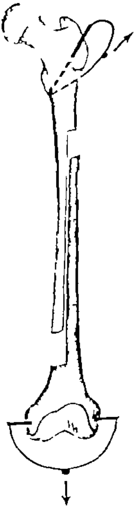
Z-osteotomy of femur

6 A long antero-lateral incision extending along the whole of the femoral shaft is made. The rectus femoris is separated from the vastus lateralis. The fibres of the vastus intermedius are split longitudinally and the periosteum is divided. A Z-osteotomy with the main longitudinal cut antero-posteriorly is made with an electric circular saw for a distance of slightly less than half of the total length of the femur an average of about 6–8 inches depending on the size of the patient. After careful haemostasis the aponeurosis is sutured with interrupted catgut and the skin with continuous silk.

Method of bone distraction

7 The patient is then placed on an apparatus for bone distraction. Two Kirschner wires or preferably two Steinmann pins are used one is inserted antero-posteriorly at the base of the greater trochanter and the other through the supracondylar region of the femur Two stirrups are attached to the two Steinmann pins, with the proximal stirrup for counter traction and the distal stirrup for traction. Appropriate weights are attached to the distal stirrup in order to obtain the maximum desirable distraction in about 3–4 weeks from the operation. The direction of the two pulls is varied, so that the gap between the two fragments is closed. Immobilization with traction is maintained until the strength of the callus allows its removal, usually in about 4–5 months.

Knee exercises must be carried out from the sixth week onwards.



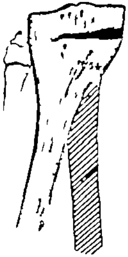
Osteotomy for Correction of Deformity due to Asymmetrical Epiphyseal Growth

Normal anatomy

8 An angular deformity of the shaft of a long bone may be produced by premature fusion of one half of the epiphyseal plate which can occur as a result of injury or disease. This is best illustrated by taking the upper end of the tibia as an example. The normal anatomy is shown.

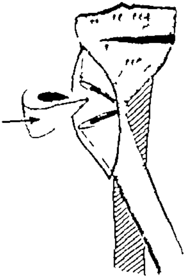
Fusion producing deformity

9 If the outer half of the upper epiphyseal plate is damaged and becomes fused the inner half may continue to grow and so produce a valgus deformity Correction will be necessary when the malalignment is considered to be sufficient to result in abnormal joint stress which may lead to osteoarthritis. As a general rule operation will be indicated if there is 15 degrees or more of angulation in any direction



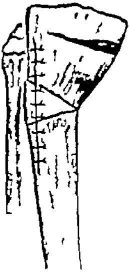
Re-alignment

10 A longitudinal incision is made to expose the uppermost third of the tibial shaft. The periosteum is divided and stripped from the underlying bone An area of bone as is compatible with easy access should be exposed 1-2 inches below the epiphysial plate The bone is divided either by drilling a series of transverse holes and completing the cut with an osteotome or with an electric saw If the deformity is severe it will be necessary to divide the fibula to allow correction The limb is now re-aligned by opening up a gap on the outer side of the osteotomy In order to encourage union and maintain stability a suitable wedge of refrigerated homogenous bone is fitted accurately into the gap (alternatively the gap may be packed with cancellous bone chips) If the undamaged half of the epiphysial plate is still open (as in the illustrated example) the deformity should be slightly over-corrected to allow for further growth which will tend to reproduce the deformity



Closure of periosteum

The periosteum is closed with chromic catgut and the skin with black silk. A well padded above-knee plaster is applied.
This method is particularly satisfactory when, as is usually the case, it is important to preserve the length of the limb If, for example, a wedge of bone is excised and the gap closed there will be some relative shortening



POST-OPERATIVE CARE

DURING THE GROWTH PERIOD

The plaster is split and the patient is kept in bed for the following fortnight. The plaster and stitches are removed 2 weeks after operation. Radiographs are taken to determine the position of the graft and a new plaster from foot to groin is applied. A week later the patient can be discharged in plaster if there are no complications. The plaster must be kept on for 8 weeks, at the end of which time new radiographs will show whether it can be safely removed.

INEQUALITY IN THE ADULT

Shortening of the normal leg

The patient's leg is immobilized in a Thomas's splint for the 8 post-operative weeks. No plaster is necessary. The stitches are removed on the fourteenth day and quadriceps exercises are instituted from the second week post-operatively. Four weeks after the operation the patient is allowed to sit on the side of the bed and encouraged to extend the leg actively as the muscles now adapt themselves to the new bone length. After the fifth week the patient is allowed to stand with elbow crutches. On an average after the eighth week the patient can walk with two sticks and full activity is quickly regained.

Lengthening of the short leg

Complications

The patient must be watched carefully, the circulation of the toes and the ability to dorsiflex the foot being observed. At the slightest sign of arterial or nerve interference distraction must be reduced. Ischaemia from arterial spasm and drop foot from paralysis of the lateral popliteal nerve have been reported after excessive lengthening (more than 3 inches for an average femur) or else in cases with more moderate lengthening (that is about 2 inches) which are distracted too rapidly. Recovery of the circulation usually follows but not always that of the nerve. A stiff knee is another complication that may follow this procedure.

Osteotomy for asymmetrical epiphysial growth

There should be no need to change the original plaster provided it is satisfactory and x-ray examination at 8 weeks shows that alignment is maintained. After 8 weeks weight bearing may be allowed in the plaster. Union can be expected to be complete in 12–14 weeks in children.

Complications

Although vascular complications and non-union are possible after an osteotomy at this site, they should not occur if the operation is carried out carefully and the post-operative immobilization is adequate.

[*The illustrations for this Chapter on Growth Disturbances: Equalization of Lower Limbs were drawn by Miss M. C. McLarty.*]

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PERIPHERAL NERVE INJURIES RECONSTRUCTIVE TECHNIQUES

DONAL BROOKS, M.A., M.B., F.R.C.S. (I.)

Consultant Orthopaedic Surgeon Barnet General Hospital Hertfordshire Consultant Orthopaedic Surgeon at Heritage Schools and Hospital Chailey Clinical Research Assistant Institute of Orthopaedics London

PRE-OPERATIVE

General indications

Reconstructive techniques may be required to improve the function of a limb in which there is a flaccid paralysis due to (1) a failure of recovery after nerve repair (2) an irreparable nerve lesion or (3) when the duration of paralysis exceeds eighteen months (when nerve repair cannot be expected to restore motor power of functional significance) The technique most commonly employed is tendon transfer

Principles of operation

Radial nerve paralysis

The functional disability from a lesion of the radial nerve is loss of active dorsiflexion of the wrist, fingers, and thumb, and loss of radial abduction of the thumb The flexor carpi ulnaris is transplanted into the common extensor tendons and extensor pollicis longus. The pronator teres is transplanted into the extensor carpi radialis brevis. If the palmaris longus is present then it is used to activate the abductor pollicis longus.

Median nerve paralysis

Loss of active flexion of the index finger and thumb together with loss of palmar abduction of the thumb follow a high lesion of the median nerve. The extensor carpi radialis brevis is transplanted into the flexor pollicis longus. The profundus tendon to the ring finger is used to flex the index finger The distal stump of the profundus tendon to the ring finger is button-holed into that of the little finger In this way three profundus tendons are used to flex four fingers.

General contra-indications

Joint stiffness.—There should always be a full range of passive movements of the relevant joints no tendon transfer can be expected to increase joint mobility The motor tendon to be transferred must be of normal strength because after transplantation its action is inevitably weakened. Excessive scarring of the skin and subcutaneous tissue *in the* line of the re-routed tendon prejudices the result of operation by preventing free gliding movement of the tendon.

Anaesthesia

General anaesthesia is best, though local anaesthesia can be used if on general grounds it is considered desirable.

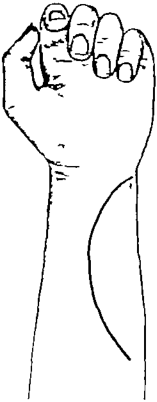
Position of patient

The arm should be placed on an arm extension The limb should be exsanguinated by means of an Esmarch bandage (*see* Volume 1 Part I, page 89) and a bloodless field maintained by a pressure cuff on the upper arm. If local anaesthesia is used the addition of adrenaline (1 200 000) will help to diminish bleeding

THE OPERATIONS

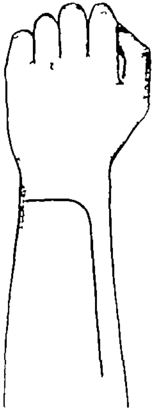
TENDON TRANSFER FOR RADIAL NERVE PARALYSIS

Anterior incision



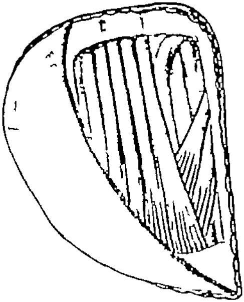
1 On the flexor aspect of the forearm a long curvilinear incision is made extending from the pisiform proximally to the junction of the uppermost and middle thirds of the forearm.

Posterior incision

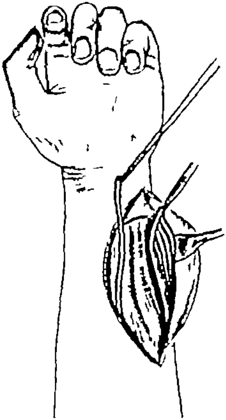


2 On the dorsum an L-shaped incision is used, the transverse component of which lies at the level of the proximal border of the extensor retinaculum

Identification of tendons

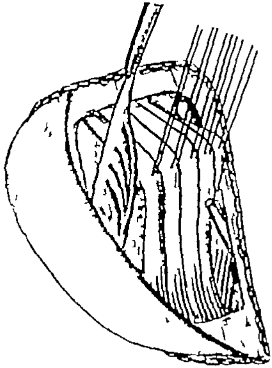


3 Through the dorsal incision a rectangular window is cut in the deep fascia covering the extensor tendons. The distal border of this rectangle is in effect formed by the proximal edge of the extensor retinaculum. Through this window the extensor tendons of the thumb and fingers are isolated and picked up by guide sutures. In the usual transplant the tendons of extensor indicis and extensor minimi digiti are ignored. The tendon of abductor pollicis longus is also identified and picked up with a guide suture.



Division of flexor carpi ulnaris

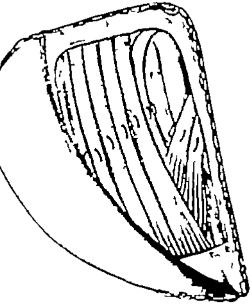
4 Through the anterior incision flexor carpi ulnaris is divided at its insertion and freed by sharp dissection from its origin from the ulna. During this part of the dissection care should be taken to secure all potential bleeding points. The muscle is mobilized to the upper third of the forearm. Through the same incision, the palmaris longus—if present—is mobilized throughout the extent of the incision.



Withdrawal of tendons into dorsal incision

5 Oblique tunnels are then made between the superficial and deep fascia, extending from the dorsal incision around the ulnar and radial borders of the forearm respectively. Through these tunnels the freed tendons of flexor carpi ulnaris and palmaris longus are withdrawn in such a manner that their line of action corresponds as closely as possible to that of the tendons into which they are being transplanted. The anterior incision is then closed.

Implanting of tendons



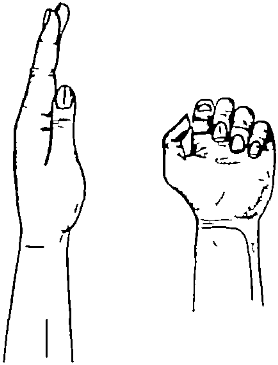
6 An assistant now holds the wrist in full dorsiflexion and the metacarpophalangeal joints in the neutral position with the interphalangeal joints flexed. Any slack in the extensor tendons is then taken up by means of the guide sutures and by careful adjustment the correct tension is applied to each tendon. When this has been achieved a haemostat clamps all the guide sutures together. Each tendon is then split.

The muscle tissue is now excised from the terminal part of the tendon of flexor carpi ulnaris and this tendon is passed through the split extensor tendons obliquely. The tendons are sutured with a continuous weaving stitch of black silk. The palmaris longus is buttonholed in a similar fashion into the long abductor of the thumb.

When there is paralysis of the dorsiflexors of the wrist, the vertical component of the L-shaped incision is extended proximally to allow for the identification and detachment of the tendon of pronator teres from the radius. This tendon is then buttonholed into the short extensor of the wrist in a similar manner to that already described.

TENDON TRANSFER FOR MEDIAN NERVE PARALYSIS

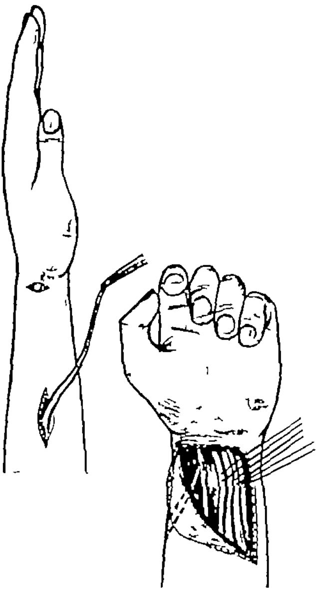
Incisions



7 (1) Over the insertion of extensor carpi radialis longus.

(2) Over the radial border of the lowest third of the forearm.

(3) An L-shaped incision over the front of the wrist joint and lower forearm.

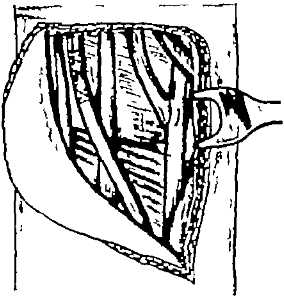


Detachment and withdrawal of tendon

8 The tendon of extensor carpi radialis longus is identified and detached from its insertion. It is then withdrawn into the forearm incision. Through the anterior incision, the tendon of flexor pollicis longus is identified and picked up with a guide suture. The extensor carpi radialis longus is then withdrawn into this incision, passing superficial to the deep fascia. The first two incisions are closed.

Implanting of tendon

9 The tendon of extensor carpi radialis longus is then buttonholed into that of flexor pollicis longus. Care should be taken that this is not done under too great tension. Tension should be such that with the wrist in the neutral position the interphalangeal joint of the thumb is flexed to about 10 degrees. The tendons of flexor digitorum sublimis together with the median nerve are then retracted medially thus exposing the profundus tendons. Guide sutures are then inserted into the tendons running to the index, ring and little fingers.



Transfer of finger tendons

10 The tendon to the ring finger is then divided about 1 inch above the wrist joint. The tendon to the index finger is divided in a similar manner The proximal stump of the tendon to the ring finger is then united to the distal stump of that of the index by a direct suture with stainless steel wire. The tension here should be such that with the wrist in the neutral position the pulp of the index finger can be approximated to that of the thumb Finally the distal stump of profundus to the ring finger is buttonholed into that of the little finger The forearm incision is then closed.

POST-OPERATIVE CARE

TENDON TRANSFER FOR RADIAL NERVE PARALYSIS

The hand and forearm are immobilized in a well-padded plaster which maintains the wrist in full dorsiflexion, the metacarpophalangeal joints in the neutral position, and the interphalangeal joints flexed. Immobilization is maintained for a total period of 8 weeks during which time no active movement should be attempted. This is followed by active re-education of the tendon transfer. For the first week the anterior part of the plaster is retained for use between treatments.

TENDON TRANSFER FOR MEDIAN NERVE PARALYSIS

The hand is immobilized by a dorsal plaster slab which maintains the wrist in the neutral position. The fingers and thumb are flexed over a pad of wool in the palm of the hand and maintained by a crepe bandage. No active or passive movements are permitted for three weeks, after which time the plaster and stitches are removed. Active re-education of the tendon transfer is then begun, the plaster back slab being continued for a further week.

For Chapters on Tendon Transfer for Thenar Paralysis and Tendon Transfer for Ulnar Nerve Paralysis, *see* Tendon Transfers in the Hand (Volume 6 Part X)

[*The illustrations for this Chapter on Peripheral Nerve Injuries Reconstructive Techniques were drawn by Mr J Wheldon*]

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POLIOMYELITIS RECONSTRUCTIVE TECHNIQUES

DONAL BROOKS, M.A., M.B., F.R.C.S. (I)

Consultant Orthopaedic Surgeon Barnet General Hospital Hertfordshire Consultant Orthopaedic Surgeon at Heritage Schools and Hospital Chailey Clinical Research Assistant Institute of Orthopaedics London

PRE-OPERATIVE

General indications

The paralytic effects of poliomyelitis may be considerably mitigated by reconstructive surgery The most important indications for surgery are (1) to restore muscle balance and thereby prevent deformity occurring, and (2) to improve function

In the upper limb primary consideration is given to improvement in function and this is usually achieved by tendon transplantation By contrast in the lower limb tendon transplantation is more often used in the prevention of deformity from muscle imbalance, whereas function is improved by joint stabilization, with or without a tendon transfer The emphasis in the lower limb is placed on stability which in the foot may mean fusion of several joints to give a firm base upon which to take weight. Tendon transfers can be carried out from the age of 5 years onwards. Joint fusion is usually deferred until major bone growth has ceased in the early teens.

General considerations

Reconstructive surgery should seldom be performed until two years have elapsed from the onset of paralysis. Careful attention to muscle grading is required before tendon transfers are considered. In poliomyelitis it is easy to over-estimate the strength of a paretic muscle some power is inevitably lost after tendon transfer In the lower limb there is little justification for operative intervention unless such treatment will enable supportive apparatus to be discarded, or unless no such apparatus is already worn.

In tendon transfers for muscle imbalance caution must be exercised to ensure that a secondary deformity will not result from the removal of the motor tendon.

In the foot tendon transplantation is most effective when combined with stabilization of the subastragaloid and midtarsal joints, as in this way the deforming action of body weight can be controlled. Furthermore, a triple arthrodesis of the foot should not be carried out unless muscle imbalance has been corrected by appropriate tendon transplantation, as otherwise deformity will recur with growth.

Anaesthesia

General anaesthesia is best, but local anaesthesia can be employed for tendon transplantation if this is desirable. A bloodless field is obtained by the use of an Esmarch bandage and is maintained by a pneumatic cuff applied to the proximal part of the limb (see Volume 1 Part I, page 89)

THE OPERATIONS

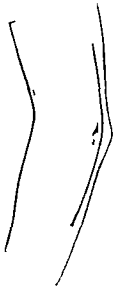
THE UPPER LIMB

Steindler Flexorplasty

This operation is designed to restore active flexion of the elbow when biceps brachii, brachialis, and brachioradialis are all paralysed. The transplant can succeed only if the flexor muscles of the forearm are almost normal in strength. A useful pre-operative test makes it necessary for the patient to maintain the elbow flexed to a right angle when the fist is tightly clenched. If this cannot be achieved it is unlikely that a flexorplasty will be successful. The patient must be warned that after operation the elbow will lack at least 80 degrees of full extension.

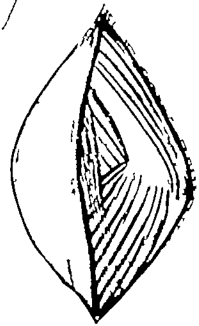
The Incision

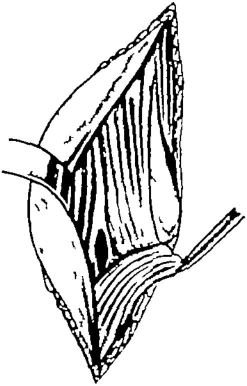
1 The incision lies over the course of the ulnar nerve in the lowest third of the upper arm and the proximal third of the forearm.



Identification of ulnar nerve

2 The anterior flap is reflected towards the radial side of the elbow. The medial intermuscular septum is defined and the ulnar nerve identified behind it.

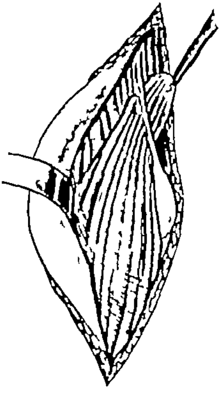




3

Detachment of flexor origin

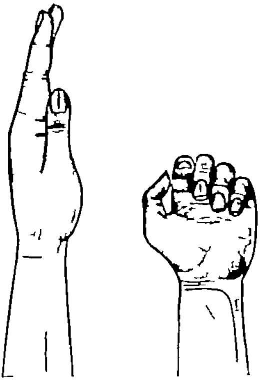
The upper border of the flexor origin is separated from the muscle fibres of brachialis. By blunt dissection the flexor mass is isolated. The flexor origin is detached from the medial epicondyle as close to the bone as possible. The mass is carefully mobilized for 2–3 inches below the medial epicondyle, care being taken to avoid damage to the motor branches of the median and ulnar nerves entering the muscle.



4

Buttonholing through medial intermuscular septum

A slit is made in the medial intermuscular septum about $1\frac{1}{2}$ inches proximal to the medial epicondyle. The flexor origin is buttonholed through this slit and sutured to itself. With the elbow flexed to a right angle there should be no undue tension at the suture line. When the medial intermuscular septum is rather flimsy the flexor origin may be attached to bone by drill holes and suitable sutures. The wound is then closed.



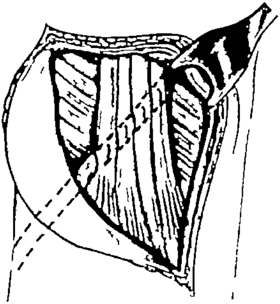
Wrist Extensor to Finger Flexors

For patients with paralysis of the finger flexors, active flexion can often be restored by transferring a normal wrist extensor. Extensor carpi radialis longus is most commonly employed as the motor tendon.

The Incisions

5 Three incisions are necessary:

(1) Over the insertion of the extensor carpi radialis longus.
(2) Over the radial aspect of the forearm about three inches proximal to the wrist joint.
(3) L-shaped incision in front of the wrist.



Detachment and transplantation of tendon

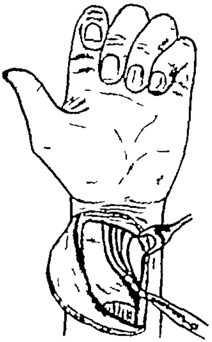
6 The tendon of the extensor carpi radialis longus is detached from its insertion, withdrawn into the forearm incision and passed subcutaneously around the radial border of the forearm to be buttonholed into the tendons of flexor digitorum profundus. Care should be taken that the transplant is not done under too great tension. As a working rule the fingers should be flexed to the same extent as they would lie in the normal relaxed hand with the wrist in the neutral position. The tendons are secured by a continuous weaving stitch of black silk. The wound is then closed.

FLEXOR TENODESIS

In certain cases there are no muscles available for transplantation owing to the extent of the paralysis. A useful hook can be made by tethering the deep flexor tendons to the radius. If the wrist is free, such a tenodesis will close on dorsiflexion of the wrist, whereas on palmarflexion the fingers will become extended. Thus, if a wrist extensor remains unparalysed active flexion of the fingers can be restored by this method. In cases in which the wrist has been fused the tenodesis results in a passive hook.

Incision division of profundus tendons

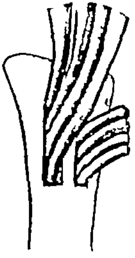
7 The incision is the same as for the previous operation. The median nerve and the tendons of flexor digitorum sublimis are retracted medially to expose the profundus tendons. These tendons are divided proximally to give as much tendon as possible. This means that the tendons will have to be dissected free from their muscle belly The pronator quadratus is incised over the radius and the periosteum stripped to expose the bone Two rows of drill holes are then made in the anterior cortex and subsequently joined to leave a bridge of bone.



Attachment of tendons

8 The profundus tendons are passed under this bony bridge and pulled tight so that with the wrist in full dorsiflexion the fingers are clenched in the palm of the hand.

Each tendon is buttonholed through itself and secured by a continuous weaving suture of black silk. The wound is then closed.



THE LOWER LIMB

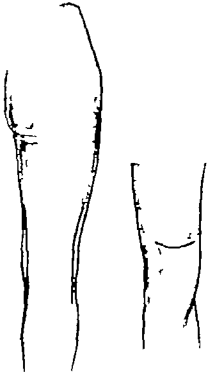
Hamstring Transplant

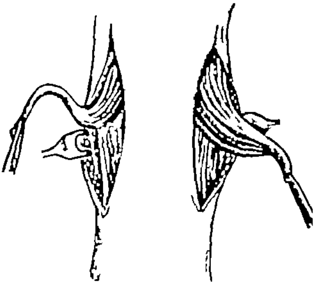
✓ If the gluteus maximus is strong it is possible to walk, even though the quadriceps muscle is totally paralysed. The knee, however is unstable, and gives way easily Increased stability can be achieved by transplanting the semitendinosus and biceps femoris muscles into the patella. This operation should not be considered unless the calf muscle is of almost normal strength otherwise genu recurvatum may develop

It should be explained to the patient that this operation will improve the stability of the knee but will not improve function appreciably

The Incisions

9 Lateral incisions are placed over the tendons of semitendinosus and biceps femoris. They should extend below the line of the knee joint to the insertions of these muscles, as it is important to obtain as much tendon as possible. An anterior incision is placed transversely over the upper pole of the patella.





Mobilization of tendons

10 The semitendinosus and biceps femoris, having been detached from their insertions, are mobilized proximally to the middle third of the thigh. It will be found that the mobilization of the biceps femoris is much more limited than that of the semitendinosus.

Attachment of tendons to patella

11 Through the anterior transverse incision the two tendons are now withdrawn subcutaneously It will be found that biceps will only just reach to the upper pole of the patella, but that there is no such difficulty with semitendinosus. If possible, a transverse hole is drilled in the upper pole of the patella and the tendon of the semitendinosus muscle passed through it and buttonholed into the tendon of the biceps muscle In the event of there not being enough tendon available to pass through bone, the tendons may be secured to the quadriceps aponeurosis. The wounds are then closed. Care should be taken to avoid damage to the lateral popliteal nerve during the mobilization of biceps femoris.

SUPRACONDYLAR OSTEOTOMY

In the growing child a flexion contracture of the knee may develop if there is a paralysis of the quadriceps in the presence of strong hamstrings. The deformity is due to shortening of the hamstring muscles and a contracture of the posterior capsule of the knee joint. While lengthening of the hamstring tendons combined with a posterior capsulotomy of the knee joint will correct the deformity this procedure may lead to over-correction and genu recurvatum.

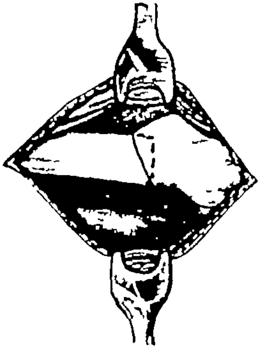
A more precise correction can be achieved by an osteotomy of the femur just above the knee joint. This operation converts an unstable flexed limb into a stable limb that will lock in extension.

Incision

12 The incision is mid-lateral 2 inches in length, situated either on the medial or lateral aspect of the lowest quarter of the femur

Site of osteotomy

13 The muscles and fascia are incised in the line of the femur which is then exposed by retraction. The periosteum is then incised vertically and freed from the anterior and posterior aspects of the femur The bone is divided with an osteotome at the point where it begins to widen. For mild degrees of flexion contracture a linear osteotomy is quite adequate, but for more marked contractures it is wise to remove a wedge of bone. The desired degree of correction is obtained by manipulation and the proximal fragment is impacted into the distal fragment. The correct degree of extension should be judged by surveying the limb as a whole, and not the osteotomy site. The wound is then closed.



TENDON TRANSFER FOR THE CORRECTION OF MUSCLE IMBALANCE IN THE FOOT

An imbalance between the invertor and evertor muscles of the foot inevitably leads to a valgus or varus deformity With an isolated paralysis of the peronei the foot swings into varus from the unopposed action of the tibialis anterior and tibialis posterior This deformity can be overcome to a great extent by transplanting the tibialis anterior laterally to the outer border of the foot. Care must be taken that over-correction does not occur the new point of insertion should be just lateral to the mid-line.

The incisions withdrawal of tendon

14 Three incisions are required

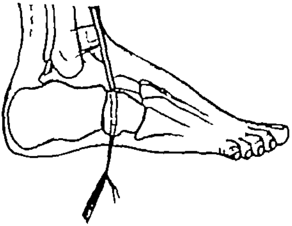
(1) Over the insertion of the tibialis anterior
(2) Over the lowest third of the leg at the musculo-tendinous junction of this muscle.
(3) A short incision over the outer border of the foot.

The tibialis anterior is detached from its origin and withdrawn into the leg incision. Through the outer incision on the foot the tendon is withdrawn so that it passes subcutaneously superficial to the extensor retinaculum. A tunnel is made in the bone at the desired point of insertion, care being taken to avoid a tarsal joint.

Tendon transplantation

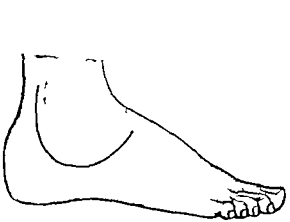
15 A double silk thread is passed through the terminal three-quarters of an inch of the tendon and threaded on one needle. This needle is then passed through the bony tunnel and emerges through the skin on the sole of the foot.

By traction on the suture the tendon is drawn into the tunnel and held by a haemostat. This suture can then be either fastened over a button on the sole of the foot or tied over a bar incorporated in the plaster This latter method allows a more even distribution of pressure on the sole of the foot.



LAMBRINUDI'S ARTHRODESIS FOR DROP FOOT

The classical indication for this operation is a paralysis of the dorsiflexors of the foot in the presence of a normal calf muscle. It is essentially a triple arthrodesis carried out with the talus in full plantarflexion. Care must be taken to ensure that the foot locks in that degree of plantarflexion most suited to the individual. Thus, in women a greater degree of plantar flexion is permitted than in men so that a high-heeled shoe can be worn. In general the foot should lock in about 20 degrees of plantarflexion



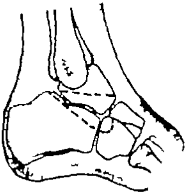
✓

The incision

16 The incision passes from behind the lateral malleolus, forwards on to the dorsum of the foot, ending medially over the talo-navicular joint.

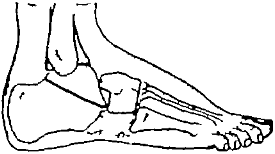
Sectioning of talus and calcaneum

17 A thick flap consisting of skin and all structures down to bone is reflected upwards to expose the subtalar calcaneo-cuboid and talo-navicular joints. The cartilage is removed from the calcaneo-cuboid joint. The subtalar joint is next opened by clearing the sinus tarsi and dividing the posterior capsule of the subtalar joint. The talus and calcaneum are next sectioned, so that with the former bone in full plantarflexion the rest of the foot can be brought up into the desired amount of equinus. This line of section is best calculated by cutting a pre-operative x-ray of the foot in full equinus.



Step excision in navicular bone

18 Finally a step is cut out of the navicular bone and the foot put together Care must be taken that the correct degree of valgus of the subtalar bony surfaces is obtained.



Elmslie's Operation for Calcaneo-Cavus Deformity

This operation is carried out in two stages. The first stage is designed to correct the cavus deformity of the foot by removing a dorsal wedge of bone from the mid-tarsal joint. At the second stage the subtalar joint is fused by removing a posterior wedge of bone which brings the foot into the plantigrade position

The incisions

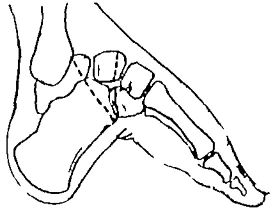
19 Two separate incisions are made

(1) A short incision is made over the dorsum and inner side of the foot in the line of the mid-tarsal joint

(2) A vertical incision to the inner side of the calcaneal tendon.

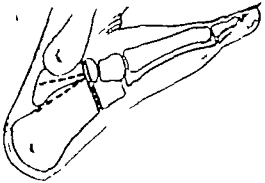
Removal of wedge from mid-tarsal joint

20 A wedge of bone based dorsally is removed from the mid-tarsal joint.



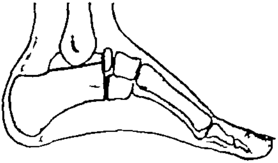
Removal of wedge from subtalar joint

21 The previous step allows full correction of the cavus deformity and exaggerates at the same time the calcaneus deformity The foot is then immobilized in plaster in the exaggerated calcaneus position. Six weeks later a wedge based posteriorly is removed from the subtalar joint. This allows correction of the calcaneus deformity



Corrected deformity

22 The extent of the wedge should enable the foot to come into the plantigrade position The limb is subsequently immobilized in plaster until fusion has occurred



POST-OPERATIVE TREATMENT

THE UPPER LIMB

Steindler flexorplasty

The elbow is maintained in about 120 degrees of flexion by means of a plaster back slab for a period of three weeks. At the end of this time the plaster and stitches are removed, and a sling is subsequently worn for a further two weeks during active re-education.

Wrist extensor to finger flexors

The wrist and fingers are immobilized in plaster with the wrist in the neutral position and the fingers semiflexed for a period of three weeks. Active re-education of tendon transfer is then begun. A protective plaster back slab maintaining the wrist in the neutral position is continued for a further two weeks.

Flexor tenodesis

The wrist and fingers are immobilized in plaster with the wrist in the neutral position and the fingers fully flexed for six weeks. No active re-education is required at the end of this time

THE LOWER LIMB

Hamstring transplant

The lower limb is immobilized in a plaster cylinder with the knee extended for a period of 6 weeks. No hip flexion is permitted for the first 8 weeks. During re-education it is sometimes helpful to use a walking caliper until 90 degrees of flexion of the knee has been regained.

Supracondylar osteotomy

The limb is immobilized in a Thomas splint with posterior slings so arranged that the correct degree of backward angulation of the femur is maintained. Alternatively immobilization can be carried out by means of a plaster cylinder Fixation is maintained until bony union has occurred

Post-operative complications

If the degree of flexion contracture is considerable post-operative paralysis of the muscles supplied by the medial or lateral popliteal nerve may occur This is essentially a traction lesion of these nerves which occurs at the time of correction Full recovery of the paralysed muscles can be expected, but it may take several months to occur

Tendon transfer for the correction of muscle imbalance

The foot is immobilized in a below-knee plaster in the corrected position for 6 weeks. During this time no weight bearing should be permitted. At the end of 6 weeks when the plaster is removed the suture usually comes away with the plaster If not, it can be cut off below skin level and usually gives rise to no trouble. It is wise to *prescribe a drop-foot apparatus for the first 4 weeks of re-education*

Lambrinudi s arthrodesis for drop foot

The limb is immobilized in a full-length plaster with the foot at a right angle and the knee in 15 degrees of flexion At 6 weeks the plaster is changed, the stitches removed and a below-knee walking plaster is applied *The total period of immobilization should be 4–5 months.*

Elmslie s operation for calcaneo-cavus deformity

An interval of 6 weeks should separate the two stages. After the first operation the limb is immobilized in a below-knee plaster with the foot in extreme dorsiflexion. After the second operation the foot is maintained for a further 10 weeks in slight plantarflexion. It is wise to refrain from weight bearing until fusion has occurred.

[The illustrations for this Chapter on Poliomyelitis Reconstructive Techniques were drawn by Mr J Wheldon]

Reference

Steindler A (1940) *Orthopaedic Operations*. 1st ed Springfield Thomas

SUSTAINED TRACTION IN ORTHOPAEDIC SURGERY

J Crawford Adams, M.D., F R.C.S.

Orthopaedic Surgeon St Mary s Hospital London

and

H. Osmond-Clarke, C.B.E., M.B., B Ch., F.R.C.S. (I.) F R.C.S. (Eng.)

Orthopaedic Surgeon the London Hospital Consultant Orthopaedic Surgeon Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

PRE-OPERATIVE

Sustained traction on a limb or on the cervical spine is used mainly to counteract deforming forces on a fracture or joint. It may be obtained by direct purchase on the skeleton or in the case of a limb by means of adhesive strapping applied to the skin.

Indications for skull traction

Skull traction is the only really tolerable way of exercising prolonged traction on the cervical spine. It is therefore widely used in the treatment of dislocations and fracture-dislocations of the neck. In many operations on the cervical spine when there may be instability before, during, or after the operation it is helpful to insert skull callipers first. The preference of the authors is to use Crutchfield tongs.

Indications for lower limb traction

Certain fractures—Traction is routine in fractures of the shaft of the femur and is applicable to the management of some oblique fractures of the tibia. The use of skeletal traction in fractures was described in Part II, Volume 1

Correction of deformity—Flexion-adduction deformity of the hip if not too long established, responds well to simple traction on the limb. Flexion deformity of the knee may also be corrected in this manner but care must be taken to avoid backward subluxation of the tibia as extension occurs.

Prevention of deformity—Limb traction should be considered during the active phases of certain hip and knee diseases, such as pyogenic or tuberculous arthritis of the hip or rheumatoid arthritis of the knee. Crushing of the softened femoral head epiphysis in Perthes disease is possibly prevented by traction.

After certain operations on the hip and knee—Traction is especially valuable when joint movement is desired soon after the operation, as after arthroplasty of the hip or synovectomy of the knee.

Congenital dislocation of the hip—Traction is used to obtain gradual reduction of a congenitally dislocated hip It also affords a gentle method of reducing a displaced upper femoral epiphysis.

Relief of pain—The acutely inflamed hip joint is often more comfortable under traction than with any other form of splinting Severe sciatic pain from a prolapsed intervertebral disc responds to rest in bed with leg traction.

Methods

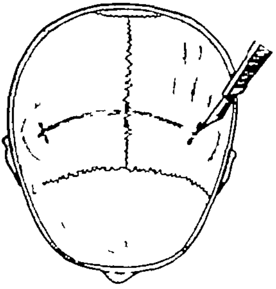
Skin traction is suitable when a pull of up to 10 pounds is required. The adhesive strapping needs periodic renewal and occasionally gives trouble from skin sensitization. Skin traction is indicated in preference to skeletal traction in children, and in adults when the pull need not be powerful or prolonged.

Skeletal traction needs anaesthesia for its application. The strength of pull is limited only by the strength of the apparatus used. Because of its greater rigidity and convenience a Steinmann pin is preferred to a Kirschner wire for transfixion of the bone

For most forms of traction it is advisable to raise the foot of the bed a few inches on blocks so that the body weight provides counter-traction.

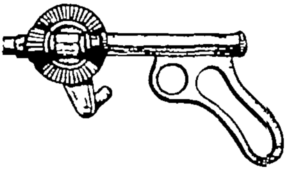
THE OPERATION

SKULL TRACTION



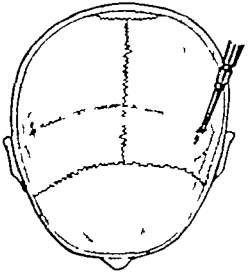
Preparation of scalp

With the patient lying on his back the mid-line of the skull (that is, the sagittal suture) is visualized and a line across it at right angles in the plane of the tips of the mastoid processes. Application of the callipers in this line ensures a pull in the axis of the cervical spine. The hair is shaved over an adequate area. The fully opened callipers are used as markers, and with local anaesthesia stab wounds are made down to bone.



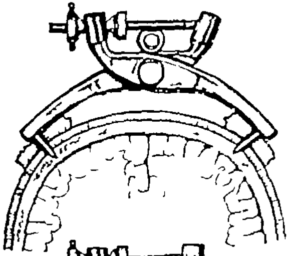
Apparatus

A special drill with a guard to prevent penetration of more than 3 mm. in children and 4 mm. in adults is used to bore two holes for the reception of the points of the callipers. The drill point is 2 mm. in diameter



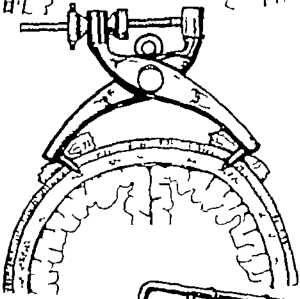
Application

3 The callipers should be inserted almost at full span the tips should be well embedded in the cancellous bone at right angles to the calvarium. The puncture wounds are protected by sterile gauze soaked in Mastisol. The callipers are locked in position by tightening the outer screw first while the inner one is left loose the inner screw is then tightened. During the first 3 or 4 days it is wise to tighten the grip of the callipers daily. The traction cord is tied to the hole in the stirrup beneath the screw



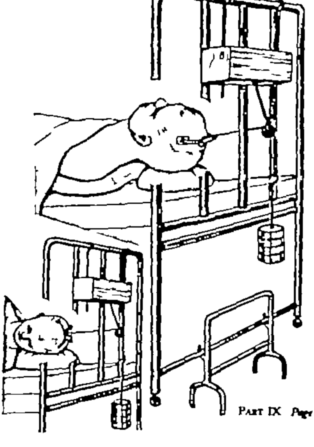
Incorrect application

4 It is a mistake to apply the callipers with the points too close together so that there is an inadequate "bite" in the bone. If this is done there is a risk of the callipers pulling out when traction is applied.



Maintenance of traction

5 When the callipers have been applied traction is maintained over a pulley attached to the raised head of the bed. The pulley and the patient are so disposed that the pull is in the long axis of the neck. The neck is now so well controlled that the patient can be turned from side to side without upsetting the mechanical arrangements. It is not usually necessary to use more than 15-20 pounds of traction but a weight of up to 35 pounds is sometimes required for stubborn lower cervical fracture-dislocations. Traction of this order should not be used for long when reduction is achieved (or when only a steadying pull is required, as for example after cervical laminectomy and fusion for cervical spondylosis) the weight should be reduced to something of the order of 5 or 6 pounds.

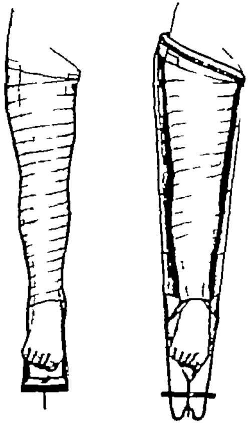


LOWER LIMB TRACTION

Skin traction

6 The skin is first washed and shaved. One-way-stretch adhesive extension strapping 3 inches wide is applied to each side of the leg from the middle of the thigh to the malleolus. For "sliding" traction a continuous length of strapping is used, with a wooden spreader at the bottom of the loop opposite the foot. For fixed traction in a Thomas's splint two separate pieces of strapping are applied, and the distal parts are folded into tapes to be tied over the foot of the splint. In each case the strapping must be held firmly to the leg by crepe bandages.

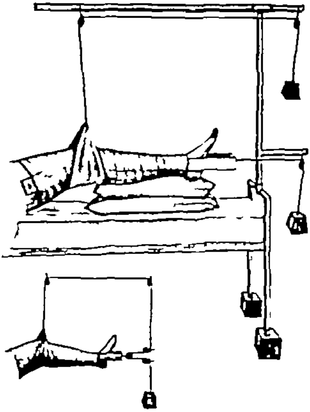
In "sliding" traction a cord suspending an appropriate weight over a pulley is attached to the centre of the spreader. In fixed traction the pull is adjusted by the use of a short stick as a Spanish windlass, traction being increased by twisting the tapes. Light traction on the splint itself is often advisable to avoid undue pressure in the groin from the ring of the splint.



Hamilton Russell traction

7 With this technique of traction-suspension a canvas sling to support the limb under the knee is combined with skin traction. By holding the knee flexed about 30 degrees rotation is controlled and the limb lies in a position of comfort. Russell's original method of passing the cord around five pulleys, with but a single weight (see inset) is ineffective unless excessive friction in the pulleys can be eliminated. The simpler modification shown is more satisfactory.

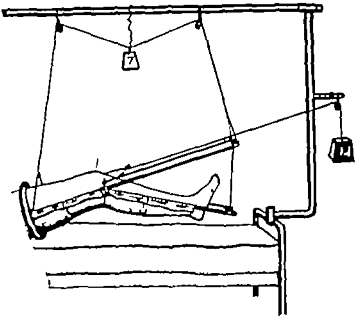
Russell traction is particularly suitable for the treatment of certain conditions in or about the hip such as trochanteric fractures of the femur or after arthroplasty of the hip. It is not advised for fractures of the shaft of the femur because there is no provision against sagging of the fragments.



Thomas's splint with skeletal traction

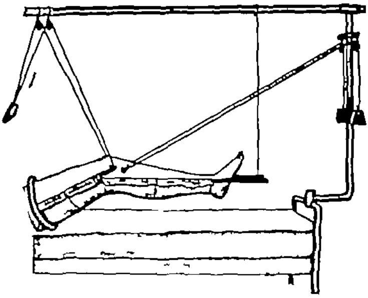
8 A Steinmann's pin is passed through the tibial tubercle. A Thomas's splint of the correct size is applied and the slings are adjusted under the thigh so that about two-thirds of the limb lies anterior to the side bars of the splint. The knee flexion piece is clamped to the side bars opposite the knee joint and slings are adjusted under the calf. The angle of knee flexion is controlled by a cord tied from the foot of the splint to the foot of the knee flexion piece. An appropriate weight is applied to the Steinmann's pin through a Böhler stirrup. The splint must be suspended from an overhead beam so that the leg hangs free and does not rest on the bed. A method of suspension is illustrated.

This form of traction is suitable for femoral shaft fractures in the adult. Knee exercises may be given by temporarily untying the flexion piece from the foot of the splint.



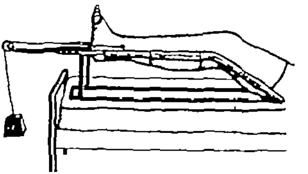
Fisk traction

9 This method was devised for the treatment of supracondylar fractures of the femur. A Thomas's splint modified by removal of the part beyond the knee is used with a hinged knee flexion piece. By working the cord attached to the splint at the level of the knee the patient can himself assist his active knee flexion and extension exercises. Traction on the limb is maintained throughout the movements.



Traction for unstable tibial fracture

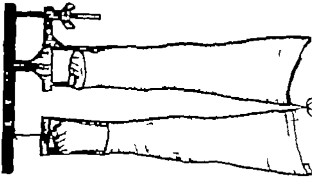
10 Oblique fractures of the tibial shaft with a pronounced tendency to shortening and angulation are usually best managed by open reduction and internal fixation. When this is contra-indicated control of the fracture may be obtained by skeletal traction through the lower end of the tibial shaft, the pin being incorporated in an above-knee plaster to maintain alignment. The limb lies on a Braun's frame, and traction is applied to a stirrup threaded over the projecting ends of the pin. The plaster should be adequately padded, particularly in front of the knee, to obviate any risk of excessive pressure against the skin when traction is applied.



"Well-leg" traction

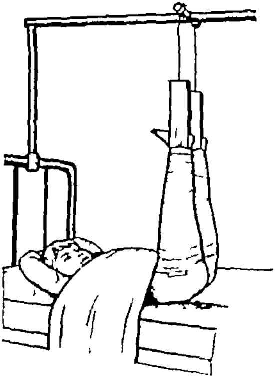
11 Traction on a limb may be obtained against a thrust from the sole of the opposite, "well," leg. The sound limb is immobilized in plaster to the upper part of the thigh with the knee almost fully extended. The traction apparatus, consisting essentially of a screw-operated lever arm, is incorporated rigidly in the lower part of the plaster. Traction on the ill leg is through skin strapping or through a Steinmann's pin in the lower end of the tibia. The traction cord is tied to the lever arm of the apparatus and the pull is controlled by adjusting the spring-loaded screw. The hip on the ill side is pulled into full abduction and the opposite hip becomes fully adducted, but flexion and extension may still occur.

"Well-leg" traction was introduced for the treatment of trochanteric fractures of the femur. Although it is now seldom used for this purpose it is a useful method of correcting an adduction deformity at the hip. By applying traction to the sound limb and the plaster to the bad one the method may also be used in reverse to correct an abduction deformity at the hip.



"Gallows" traction

12 Fractures of the femur in children up to 4 years old are best treated by suspending both lower limbs from an overhead beam. Skin traction is used and the cords are adjusted so that the buttocks are lifted just clear of the bed. The weight of the lower part of the trunk is sufficient to correct both shortening and angulation.



COMPLICATIONS AND DIFFICULTIES

Skin traction may occasionally give rise to contact dermatitis. When the skin is sensitive to adhesive strapping traction may be obtained by binding strips of webbing to the skin with Unna's paste or Viscopaste bandages.

Skeletal traction is often complicated by mild infection where the pin penetrates the skin. Occasionally the infection extends along the pin track in the bone, especially if the pin is allowed to rotate. Serious infection of the bone is however very unusual. The calcaneum has the worst reputation in this respect and for this reason it should never be used for prolonged traction.

Steinmann's pins occasionally cut out of the bone, especially in old persons. To avoid this complication the pin *should be passed through the bone in a plane* well behind the tibial tubercle.

It is unwise to pass a pin through a muscle immediately proximal to the joint that it moves, because the normal gliding of the muscle over the bone is thereby prevented and joint movement may be impaired permanently. For this reason skeletal traction through the lower end of the femur is to be avoided whenever possible.

[*The illustrations for this Chapter on Sustained Traction in Orthopaedic Surgery were drawn by Miss Christine Lamb.*]

DIVISION OF STERNO-MASTOID MUSCLE FOR CONGENITAL TORTICOLLIS

H. OSMOND-CLARKE, C.B.E., M.B., B.CH., F.R.C.S. (I.), F.R.C.S. (ENG.)

Orthopaedic Surgeon, the London Hospital Consultant Orthopaedic Surgeon Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

PRE-OPERATIVE

Indications

Division of the sterno-mastoid muscle is indicated in the presence of deformity from a contracted sterno-cleido-mastoid muscle which is producing a cosmetic blemish sufficient to distress parents or patient.

Contra-indications

It is wise always to examine the cervical spine by radiography if there are bony abnormalities (as in the Klippel-Feil syndrome) division of the sterno-mastoid muscle is unlikely to help furthermore, stretching and manipulating the neck under anaesthesia might cause serious neurological complications.

The best time for operation is somewhere between 8 and 10 years of age in adults little correction can be hoped for because there are secondary contractures of the other soft tissue structures.

Anaesthesia

General anaesthesia with endotracheal tube is recommended.

Position of patient

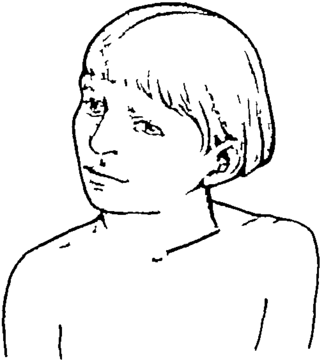
A low pillow is placed between the shoulder-blades, and the chin is kept rotated to the opposite side. After the skin has been prepared two towels are placed under the head, the top towel being folded over to cover the head completely from the point of the chin upwards. Other towels are arranged appropriately

THE OPERATIONS

The muscle may be divided at its lower or upper attachment. Division at the lower end is the easier but it leaves a scar which may cause some distress to a girl.

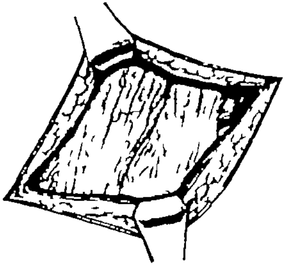
DIVISION OF LOWER ATTACHMENT

The Incision

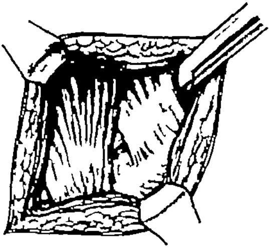


1 A transverse incision is made about an inch above the clavicle. It is helpful to pull the skin down until the area to be divided lies over the clavicle skin and platysma can then be cut through neatly in one stroke.

Exposure



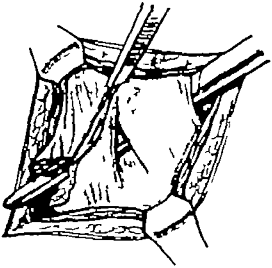
2 The skin and platysma are divided, exposing the taut sternal and clavicular heads of the sterno-mastoid muscle covered by fascia. The external jugular vein presents near to the posterior margin of the muscle.



3

Passage of dissector

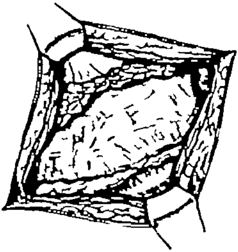
The fascia covering the sterno-mastoid muscle is cleaned off and the anterior and posterior surfaces of this muscle are clearly exposed by blunt dissection. The dissector is passed behind the muscle, working alternately from the medial and from the lateral sides, always keeping close to the deep surface of the muscle.



4

Division of muscle

The muscle is divided about an inch above the clavicle it is unwise to detach it from the bone because ossification, producing an unsightly protuberance, may occur if a haematoma forms. If the muscle is divided by a series of cuts intramuscular vessels can be caught as they are cut, and ligated or cauterized before the muscle retracts on complete division.



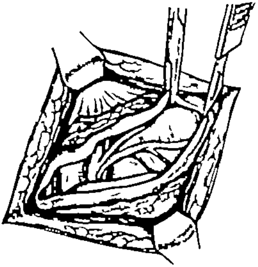
5

Inspection of operation area

After complete division of the sterno-mastoid muscle its posterior sheath, the deep cervical fascia and the large vessels deep to it are inspected.

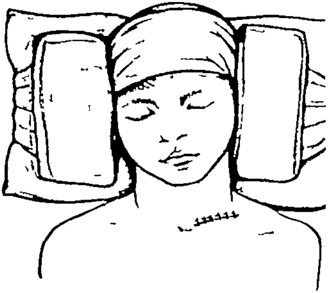
Division of posterior sheath and deep cervical fascia

6 The posterior sheath and the deep cervical fascia are usually *contracted* and should be divided. Because of the immediate proximity of the internal jugular vein, the thyro-cervical axis with its transverse cervical and transverse scapular branches, and the subclavian artery and vein, this step of the operation should be performed with great care. The proximity of these important structures indicates the dangers which could be encountered by subcutaneous tenotomy of the muscle a procedure which is still practised by some.



Correction of deformity

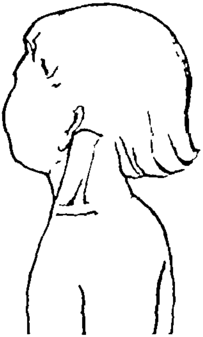
7 Before the platysma and skin are closed the deformity is overcome by gentle manipulation, bending the head towards the opposite shoulder and rotating the chin towards the side of operation. After this the wound is closed and the head is held in the corrected position by a head band attached to a pillow fixed by sandbags.



DIVISION OF UPPER ATTACHMENT

The incision

8 Division of the sterno-mastoid at its upper attachment has the advantage that the scar can be hidden above the hair-line but the operation is more difficult than division of the lower attachment. If correction of torticollis has been delayed until late adolescence or early adult life it is wise to divide the muscle at both ends (and wise to correct gradually by continuous halter or skull traction rather than by a vigorous manipulation under anaesthesia which may damage important structures such as the brachial plexus). After shaving the area an incision is made beginning behind the pinna at the level of the lower margin of the external auditory meatus, the incision curves upwards and backwards across the base of the mastoid process and extends backwards along the anterior one-third of the superior nuchal line

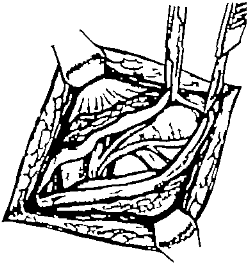


Division of muscle

9 The skin and subcutaneous tissues are divided and the muscle is detached close to its bony attachment. Care should be taken to avoid the main stems of two branches of the external carotid artery—the posterior auricular in front and the occipital behind. The former is liable to injury in dividing those fibres of the sterno-mastoid which are inserted into the anterior margin of the mastoid process (see Illustration 11)

Division of posterior sheath and deep cervical fascia

6 The posterior sheath and the deep cervical fascia are usually contracted and should be divided. Because of the immediate proximity of the internal jugular vein, the thyrocervical axis with its transverse cervical and transverse scapular branches, and the subclavian artery and vein, this step of the operation should be performed with great care. The proximity of these important structures indicates the dangers which could be encountered by subcutaneous tenotomy of the muscle, a procedure which is still practised by some.



Correction of deformity

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DIVISION OF UPPER ATTACHMENT

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Division of muscle

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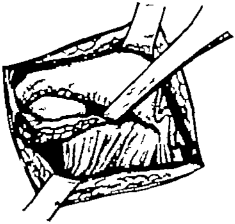
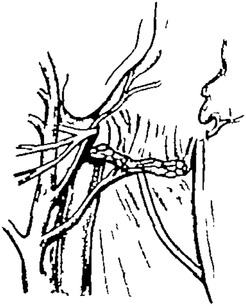


Detachment from bone

10 The remainder of the muscle is detached from the skull by a rugine. The deformity is overcome by manipulation (or by traction) and the wound is closed. After-treatment is the same as for division at the lower end.



Anatomical relationships

11 This illustration shows the important vessels and nerves in the area. Note the close relationship of the accessory nerve—hence the wisdom of dividing the muscle at its bony attachment. The posterior auricular and occipital arteries and the jugular vein are clearly shown, with the facial nerve lying deep to the anterior border of the muscle.

Application of plaster collar

12 When the stitches are removed in 5–7 days a plaster-of paris collar is applied, with care to ensure that the deformity is slightly over-corrected.

POST-OPERATIVE CARE

The plaster collar is retained for 6 weeks. Thereafter a prolonged period (up to 1 year) of re-education in maintaining correct head and neck posture is required. The older the child the more necessary and the more rigorous this course must be.

[The illustrations for this Chapter on Division of the Sterno-mastoid Muscle for Congenital Torticollis were drawn by Miss Christine M. Lamb.]

OCCIPITO-CERVICAL FUSION

H OSMOND-CLARKE, C.B.E., M.B., B.CH., F.R.C.S. (I.), F.R.C.S. (ENG.)

Orthopaedic Surgeon the London Hospital Consultant Orthopaedic Surgeon Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

PRE-OPERATIVE

Indications

This operation is seldom required. It is indicated in fractures or dislocations that produce serious instability of the atlanto-occipital or atlanto-axial joints, and in some rare conditions like platybasia (basilar invagination) when a neuro-surgeon has had to perform a suboccipital decompression with removal of the arch of the atlas and perhaps of the axis.

It is wise to do the fusion as a second-stage operation 3 weeks after the decompression if the patient is not fit enough for the whole procedure at one sitting

The grafts, taken either from the tibia or the ilium, can be conveniently cut while the neuro-surgeon is performing the decompression and they should be kept in sterile containers in deep-freeze conditions until the second operation.

The neuro-surgeon and orthopaedic surgeon should operate together at both stages.

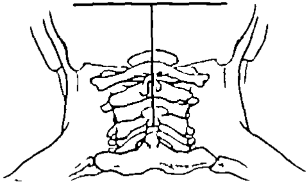
Anaesthesia

General anaesthesia with an endotracheal tube is essential.

Position of patient

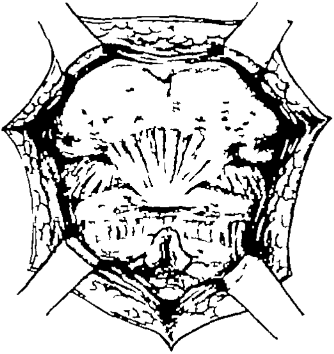
The patient lies face down with the head in a head-rest attached to the end of the operating table, and if permissible with the neck slightly flexed.

THE OPERATION



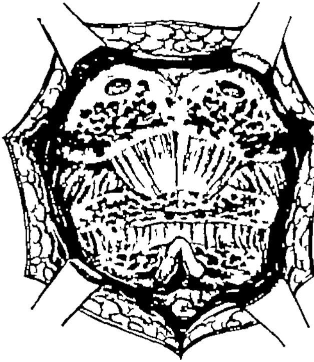
The incision

1 The cross-bow incision of Cushing gives the best exposure. The transverse limb extends for about 3 inches on each side of the external occipital protuberance along the superior curved line of the occiput and is deepened straight down to bone. The vertical limb of the incision extends in the midline from the protuberance as low as necessary to give adequate access.



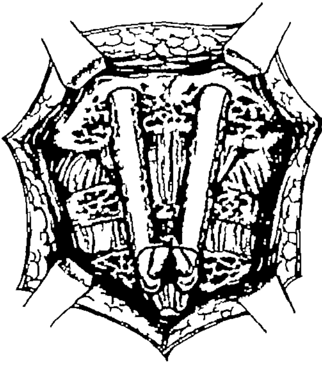
Exposure of bony surfaces

2 The muscles are stripped subperiosteally from the skull and the neural arches are exposed as for cervical fusion (see page 70)



Preparation of bony surfaces

3 The spinous processes and laminae are rawed, preferably with a fine nibbling forceps (as in fusion of the cervical spine, *see* Illustration 6 page 71) The surface of the occiput is rawed with a dental drill (most easily used in a Luck's electric bone-saw) Two holes are bored in the outer table. If tibial grafts are being used the holes should be large enough to admit their ends and they should not penetrate the inner table (*see inset*)

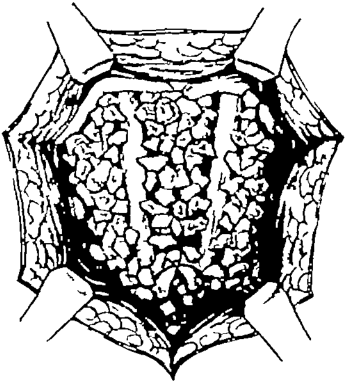


Insertion of grafts

4 Two tibial grafts are thrust into the holes in the occiput and impacted in the diploe by undoing the flexion of the patient's neck sufficiently to bring the head into the neutral position. The lower end of each graft is fixed by a wire suture passed through the base of a spinous process (or preferably round a lamina and threaded and tied through drill holes in the graft)

Insertion of bone chips

5 The whole area is filled with cancellous bone fragments except when a laminectomy of the atlas or axis has been performed it would be unwise to run the risk of the chips compressing the spinal cord or brain stem. When a decompression of the foramen magnum and a laminectomy have been necessary it is probably wiser to use a slab of iliac bone, tied above with wire through drill holes in the occiput and in the graft, and anchored below to two or more laminae by wires passed around the laminae and through drill holes in the graft. Closure of the wound may present difficulty if too bulky a graft has been used.



POST-OPERATIVE CARE AND COMPLICATIONS

"Steadying" traction of about 5 pounds with skull callipers is the most comfortable method of post-operative splinting (*see* page 68) The traction should be maintained for 8 weeks. A plaster of Paris collar (as illustrated in the Chapter on operations for torticollis, page 63) is then applied and worn for at least 3 months. Thereafter a removable plaster or moulded leather collar is worn for a further 3 months. When the plaster has been applied the patient may sit up and begin walking.

If the graft has been taken from the tibia it is probably wise to apply a walking plaster from mid-thigh to the metatarsal heads for 4–6 weeks to avoid fractures from trivial injuries.

There are no special orthopaedic complications but there may be neurological problems requiring the attention of the neuro-surgeon.

[The illustrations for this Chapter on Occipito-cervical Fusion were drawn by Miss Christine M. Lamb]

FUSION OF THE CERVICAL SPINE

H. OSMOND-CLARKE, C.B.E., M.B., B.CH., F.R.C.S. (I.), F.R.C.S. (ENG.)

Orthopaedic Surgeon the London Hospital Consultant Orthopaedic Surgeon Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

PRE-OPERATIVE

Indications

Most fusion operations on the cervical spine are performed with the object of stabilizing the joints between the fourth and fifth, fifth and sixth or sixth and seventh cervical vertebrae or any combination of these following inflammatory or degenerative processes or injury In practice this usually necessitates fusion of at least four spinous processes and laminae.

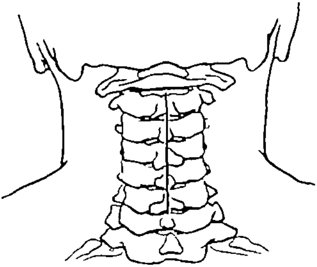
Anaesthesia

General anaesthesia with an endotracheal tube is essential Infiltration of the skin, subcutaneous tissues and muscles with a solution of 120 ml. of 0 8 per cent Xylocaine, half an ampoule of hyalase and 18 minims of 1 1 000 adrenaline helps to produce a dry field.

Position of patient

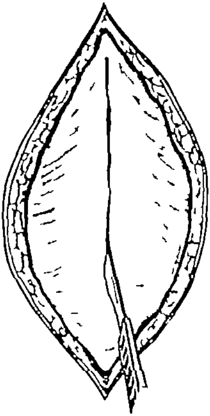
The patient is placed face down with the head in a head rest. If flexion of the neck can be allowed with safety it is an advantage, but neck flexion is not permissible if it is likely to cause dangerous instability (as in certain fracture-dislocations) Palpable bony landmarks are the external occipital protuberance and the prominent spinous processes of the second, sixth and seventh cervical vertebrae.

THE OPERATION



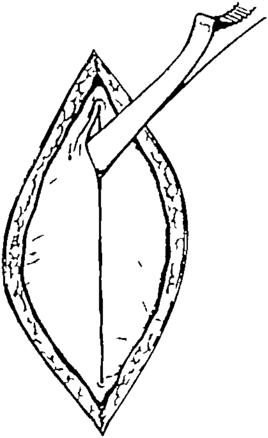
The incision

1 The skin incision extends in the midline usually from the second to the seventh spinous processes (it may be made longer if necessary) the ligamentum nuchae is incised in the same line, the muscles are separated subperiosteally and self-retaining retractors are inserted. The interspinous ligaments are excised. These are the preliminaries to commencing work on the bone of the spinous process and laminae.



Division of ligamentum nuchae

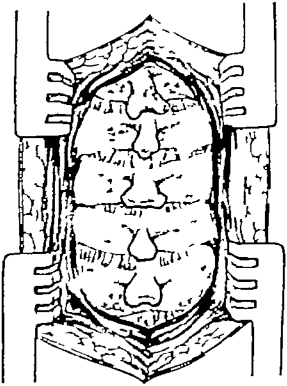
2 The dense ligamentum nuchae is incised in the midline throughout the length of the skin incision.



3

Exposure of spinous processes

When the tips of the spinous processes have been exposed by sharp dissection the muscles are stripped subperiosteally from the sides of the spinous processes and the laminae.



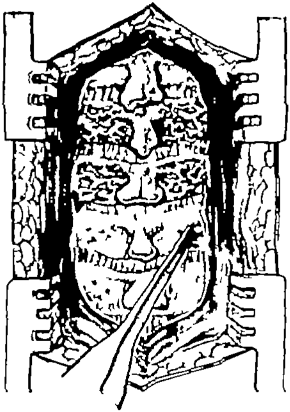
4

Removal of interspinous ligaments

Self-retaining retractors are inserted and the interspinous ligaments are removed.

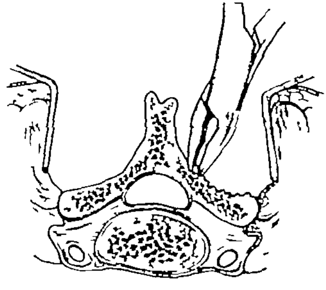
Removal of cortex

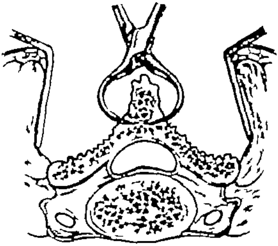
5 The cortex is removed from the sides of the spinous processes and the dorsal aspects of the laminae until freely oozing cancellous bone is exposed. This is a tedious process because the cervical spine is not so rigid as the thoracic and lumbar regions—consequently there is less "resistance" to work against.



Use of nibbling forceps

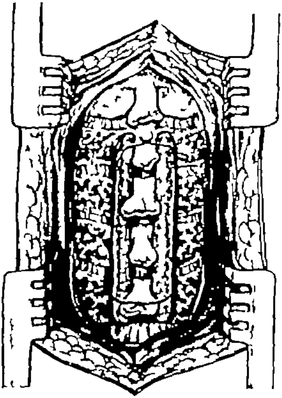
6 The osteotome, gouge and mallet must be used gently. Nibbling forceps, such as those of Pennybacker are effective and safe. The spinous processes to which the strut grafts will be tied should not be "decorticated" so extensively as the intervening vertebrae because they must remain strong enough to hold the wire suture.





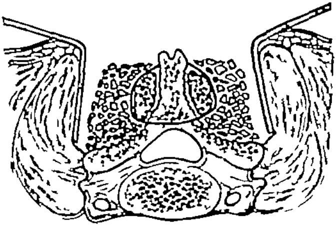
Drilling of spinous process

7 A hole is then drilled through the base of the spinous process. A convenient method of making the hole with Lewin's forceps is shown.



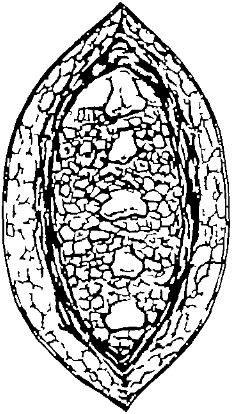
Insertion of strut grafts

8 Twin strut grafts either from the ilium or from the tibia, are placed in position alongside the spinous processes and held by a wire suture (26 or 28 standard wire gauge stainless steel) passed through the base of the spinous process.



Packing with bone fragments

9 Cancellous bone fragments are used to cover the remaining raw areas of the laminae and spinous processes. If a laminectomy has preceded the fusion operation it is unwise to use small bone fragments, and fairly large slivers of iliac bone should be used instead to reinforce the strut grafts. The wound is closed in layers muscle, ligamentum nuchae and skin. Drainage is not necessary



SPECIAL POST-OPERATIVE CARE

The patient is rolled into a previously constructed plaster of Paris bed. A turning case should also have been constructed to allow inspection of the wound, removal of stitches at the end of two weeks and attention to bony pressure points. If there is marked instability of the spine, as sometimes after an extensive laminectomy or after a fracture-dislocation it is better to rely upon skull traction (see page 62) for 3–4 weeks before a plaster bed or collar is used. Recumbency is advisable for at least one month and a plaster of Paris collar should be worn for a further two months.

[*The illustrations for this Chapter on Fusion of the Cervical Spine were drawn by Miss Christine Lamb*]

COSTO-TRANSVERSECTOMY

NORMAN CAPENER, F.R.C.S.

Consultant Orthopaedic Surgeon, Princess Elizabeth Orthopaedic Hospital and Royal Devon and Exeter Hospital, Exeter Mount Gold Orthopaedic Hospital Plymouth

PRE-OPERATIVE

General approach to the surgery of tuberculous disease

The return to radical surgery for arthrosteal tuberculosis, made possible by antibiotic control, has restored interest in the direct approach to vertebral disease as suggested by Ménard (1900) Even more direct has been the extension of this operation to include exposure of the anterior wall of the spinal canal so as to permit removal of the actual structural detail (whether bone, cartilage or granulation tissue) which may be causing spinal cord compression from in front. The antero-lateral approach to the vertebral bodies and spinal canal (or lateral rhachiotomy see page 78) has points in common with the neurosurgical approach for sympathectomy it is applicable to other purposes, for example when biopsy of the vertebral bodies may be required for neoplasms, and in which it is desirable for the approach to be extrapleural.

Operation for tuberculosis should not be embarked upon as an emergency procedure it is best planned to fit into the regimen which brings the patient into as fit a state of general health as is possible by physiological control of the diseased part in the most favourable environment and with appropriate antibiotic treatment. This stage will usually take not less than 8 months.

Principles of costo-transversectomy

The purpose of costo-transversectomy is to evacuate a paravertebral abscess and to remove other necrotic material from the central vertebral lesion. The plane of approach is the tunnel remaining after subperiosteal resection of the vertebral end of the rib leading to the central bone lesion. It is made easier of access by coincident excision of the transverse process with which the rib articulates.

Position of the patient

The patient, who will have been nursed in a posterior plaster shell, is turned on to his face upon pillows one of these is placed under the chest, the other under the pelvis with sufficient gap between to allow easy diaphragmatic movement. The arms are brought towards the head so that the shoulders are abducted and flexed and the elbows flexed, special care being taken to avoid any undue pressure upon the inner sides of the arms as they lie along the side of the table

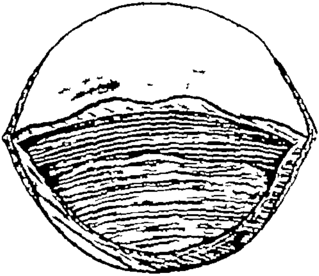
BIOPSY OF VERTEBRAL NEOPLASMS

The procedure to be described is equally appropriate for the biopsy of vertebral neoplasms. It is quickly performed and should not cause any shock. After operation for this purpose early walking may be allowed.

THE OPERATION

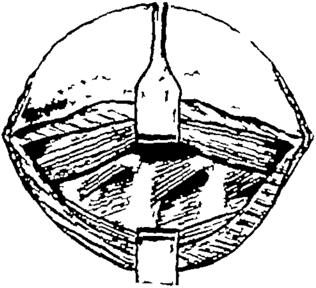
The incision

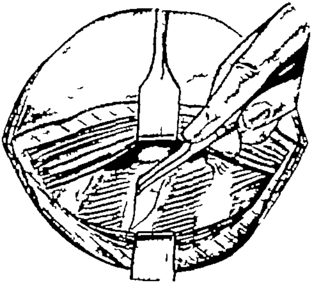
1 A curved incision convex laterally is outlined starting in the midline of the back at a point level with the second rib above the one to be excised, and extending below it for an equal distance. Away from the spine the centre of the incision lies at the angles of the ribs. The *incision is deepened through the deep fascia* and the flap thus fashioned is elevated and reflected medially



Superficial dissection

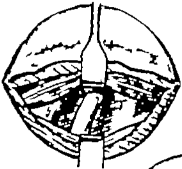
2 The trapezius muscle is incised vertically close to its origin from the spinous processes and reflected laterally to expose the *intermuscular* fascial sheet which contains the serratus posterior superior This is incised and reflected laterally off the longissimus dorsi and ilio-costalis portions of the sacrospinalis musculature which *are then separated* and the ilio-costalis retracted laterally





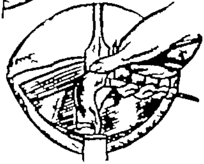
Exposure of rib and transverse process

3 The rib chosen is stripped subperiosteally from its angle to the transverse process using first a Nelson's periosteal elevator for the superficial surface and a rib raspatory for the pleural surface. Its attachments to the transverse process are excised with the levator costae muscle and the transverse process is similarly stripped subperiosteally to its base.



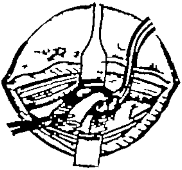
Excision of transverse process and division of rib

4 The transverse process is excised with small bone nibblers. After this it is easy to continue the stripping of the neck of the rib. Now with rib shears the rib is divided at its angle.



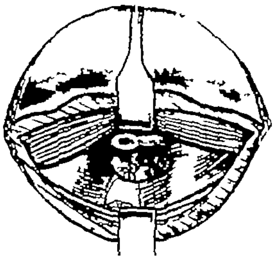
Division of remaining attachments and complete removal

5 The proximal end being grasped with sequestrum forceps, the head and neck may be rotated to allow division of any remaining ligamentous attachments, a process which can be assisted by leverage with an instrument such as Capener's laminectomy gouge. By combined twisting and levering the proximal end of the rib, it may now more or less completely be removed from the wound. Any remaining fragment can be pulled out with the small rongeurs, or lifted out with the gouge.



Evacuation of abscess

6 In this stage of the operation the paravertebral abscess will usually be opened, and will be evacuated by the suction apparatus. A tunnel lined by periosteum and costo-vertebral joint capsule will have been produced and thus will open through a narrow neck into the abscess.



The central end of the tunnel may be enlarged by gentle stretching with the surgeon's finger covered with gauze. The abscess cavity will usually be large enough to enable direct vision to be obtained of the vertebral bodies, and a rubber suction tube may be passed in front of them into the extension of the abscess upon the opposite side. If the right level has been found the main vertebral lesion may itself be seen and the central bone cavity may be curetted so as to remove necrotic bone or granulation tissue. If no abscess is encountered, the same process of rib and transverse process excision must be followed for the interspace above or below.

Closure of wound

7 When the abscess has been completely evacuated (this may be assisted by irrigation with saline solution combined with suction) the cavity is treated with 1 g. of streptomycin (in an adult patient). The longissimus and ilio-costalis are approximated, the trapezius is replaced and attached to the interspinous ligaments and the skin wound closed.

POST-OPERATIVE CARE AND COMPLICATIONS

The post-operative care after costo-transversectomy and the complications that may arise are dealt with in the Chapter on Lateral Rhachiotomy page 78

[The illustrations for this Chapter on Costo-transversectomy have been prepared by Mr J Wheldon from original sketches by Mr Norman Capener.]

LATERAL RHACHIOTOMY (ANTERO-LATERAL DECOMPRESSION)

NORMAN CAPENER, F R.C S

Consultant Orthopaedic Surgeon Princess Elizabeth Orthopaedic Hospital and Royal Devon and Exeter Hospital Exeter Mount Gold Orthopaedic Hospital, Plymouth

PRE-OPERATIVE

Indications

Whereas costo-transversectomy is mainly for the purpose of draining a paravertebral abscess, or for the curettage of cavities within the vertebral bodies, the object of lateral rhachiotomy or antero-lateral decompression is, in tuberculous paraplegia, to remove the structural features actually causing compression of the spinal cord.

General principles

The earlier stages of this operation resemble those of the costo-transversectomy operation described on page 74 It will, however be necessary to excise portions of at least two ribs particularly is this so when the patient has a very severe kyphos and the ribs are crowded together In the latter circumstance, however the severe kyphos facilitates the later stages of the operation. In order to obtain better guidance into the spinal canal, division of one *intercostal nerve may be useful, the central end being elevated and followed inwards.*

Position of patient

The patient, who will have been nursed in a posterior plaster shell, is turned on to his face upon pillows one of these is placed under the chest, the other under the pelvis with sufficient gap between to make diaphragmatic movement easier The arms are brought towards the head so that the shoulders are abducted and flexed and the elbows flexed, special care being taken to avoid any undue pressure upon the inner sides of the arms as they lie along the side of the table

LATERAL EXPOSURE OF THE LUMBAR VERTEBRAE

This is a form of lateral rhachiotomy which is suitable for the curettage of tuberculous or osteomyelitic lesions of the lumbar vertebral bodies as well as for the biopsy of neoplasms.

At the level of the lumbo-sacral joint it will be necessary to remove a portion of the posterior part of the wing and crest of the ilium.

In the upper lumbar region exposure of the vertebral bodies may also be obtained by the alternative approach which is the same as for retro-peritoneal lumbar sympathectomy

Position of patient

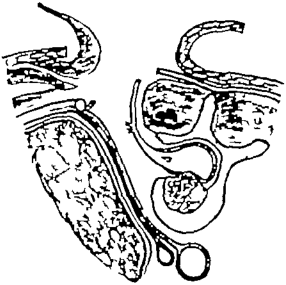
This is similar to that for the approaches in the dorsal region, the patient being on his face with pillows beneath the thorax and pelvis so as to leave the upper abdomen free for the diaphragmatic movement. It is of advantage to be able to bend the operating table so that the hips are flexed and the lumbar lordosis reduced.

THE OPERATION

The approach

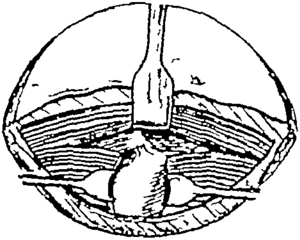
1 The approach is extrapleural, between the intercostal vessels which are depressed anteriorly with the pleura and the intercostal nerves which lie externally and posteriorly in the wound. The superficial stages of the operation are planned to provide overlapping flaps in order to facilitate primary healing.

A curved incision convex laterally is outlined starting in the midline of the back at a point 3 or 4 vertebrae above the apex of the kyphos and extending below it an equal distance. Laterally the incision extends as far as the rib angles. It is deepened through the deep fascia and the flap thus formed is reflected medially.



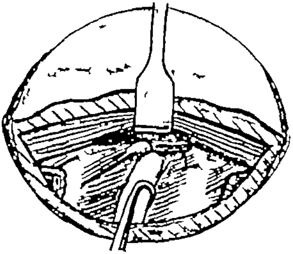
Superficial stage of dissection

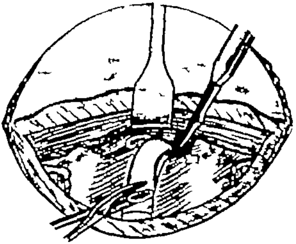
2 The trapezius muscle (and the aponeurosis of the latissimus dorsi muscle in the lower part of the dorsal region and the rhomboideus muscle in the upper) is incised vertically close to the spinous processes and reflected laterally. With it is reflected the deep intermuscular fascia to expose the ilio-costalis dorsi muscle which is incised transversely at the rib which it is proposed to follow as the main guide to the vertebral lesion.



Exposure of ribs and transverse processes

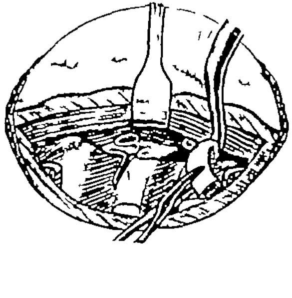
3 The central rib leading to the intervertebral level most affected, with the ribs immediately above and below are stripped subperiosteally from their angles to the costo-transverse articulations the ligaments of which are excised together with the levator costae muscles. Each of the upper two transverse processes is *similarly stripped subperiosteally*





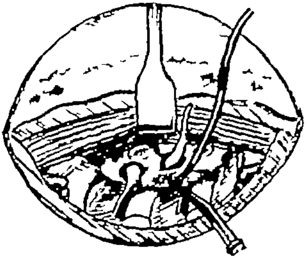
Deeper dissection

4 The two upper transverse processes are now excised to their bases with bone nibblers. The two upper ribs are cut at their angles. Each of them is grasped proximally with sequestrum forceps and, by rotating first one way and then the other the remaining attachments to the side of the vertebrae may be divided, a process that is assisted by the use of a shallow gouge measuring three-eighths of an inch or Capener laminectomy gouge. Continuing the torsional movements the entire rib end with its head may be lifted out of the wound. An abscess at this stage may be opened if so it can be evacuated now with the suction apparatus.



Approach to the spinal theca

5 The intercostal nerve and vessels below the upper excised rib are now exposed deep to the posterior intercostal membrane. The nerve is divided 1½ inches away from the spine and the central end turned medially to act as a guide to the intervertebral foramen. The intercostal vessels are left undisturbed upon the pleura and depressed with it. The uppermost and lowest nerves are separated from the vessels but not divided. From the deep surface of the lowest rib the costal pleura only will have been reflected and depressed. In cases where more room is required for the deepest part of the dissection this rib may also be excised. Rarely is it necessary to excise more than 3 ribs.



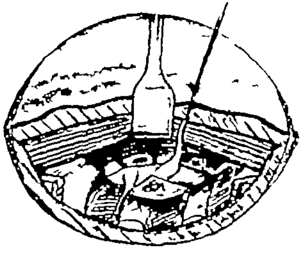
The divided nerve is followed medially to its intervertebral foramen, freeing the nerve of its communicating branches with the sympathetic chain.

The upper two pedicles are excised with small bone nibblers.

A gauze covered finger presses the pleura away from the sides of the vertebral bodies to expose the lesion and a paravertebral abscess if this has not already been opened. The latter should now be completely evacuated by saline irrigation and suction.

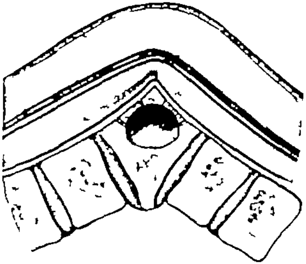
Exploration of spinal canal and decompression

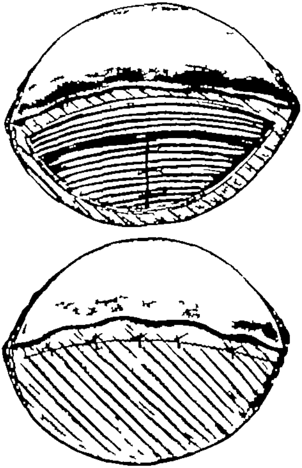
6 Excision of the pedicles will reveal the lateral aspect of the theca with the spinal nerve roots leading out of it. The actual compressing agent can be seen or can be determined by careful exploration with a blunt dissector. The central lesion will be curetted caseous granulation and fibrous tissue being removed together with sequestrated bone and intervertebral disc. Quite large masses of necrotic tissue may be encountered. Wherever possible this material should be brought forwards from the spinal canal into the vertebral body cavity before removal. When all this material has been removed from the vertebral bodies and from the anterior extra-dural space *special care must* be taken to see that, above or below the cavity which is left, there is no sharp edge over which secondary angulation of the theca can take place



Treatment of sharp angulation spurs

7 Where paraplegia is due to the sharp angulation of bony deformity special care must be taken, for the application of bone cutting tools directly to such bony spurs may be risky and offer the chance of driving the bony projection further into the spinal cord. The condition must be dealt with by undermining. First a cavity must be excavated in the vertebral body immediately in front of the base of the projection and into this cavity the projection of bone may be depressed by suitable direction of appropriate small gouges.





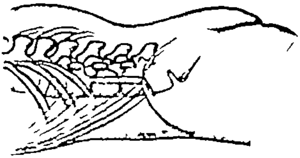
Closure of wound

8 Bleeding points being secured, the wound is dried and 1 g of streptomycin (in an adult) is put into its depth. The wound is then closed by the approximation of the ilio-costalis muscle, the trapezius muscle is stitched back to the interspinous ligaments and the skin flap is replaced and sutured.

LATERAL EXPOSURE OF THE LUMBAR VERTEBRAE

Incision

9 An angulated incision is made with a vertical limb just medial to the lateral margin of the sacrospinalis muscle and extending down to the crest of the ilium, where the incision is made to curve forwards and slightly downwards on to the buttock. The incision is deepened through the deep fascia and the *lateral flap retracted.*



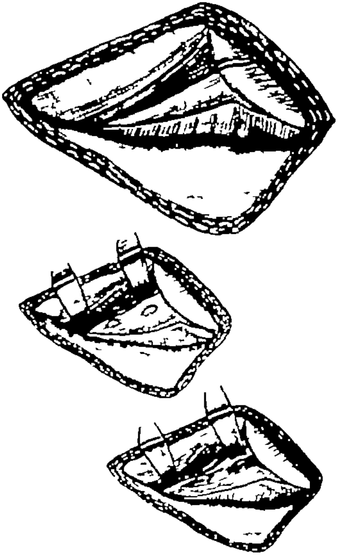
Superficial dissection

10 The aponeurotic sheath of the sacrospinalis muscle is opened close to its lateral margin the latissimus dorsi muscle is reflected laterally and it may be found helpful to detach some of its origin from the ilium.

Now the middle layer of the lumbodorsal fascia is exposed and this is followed medially to the transverse processes of the second, third and fourth lumbar vertebrae.

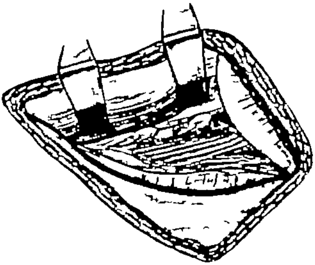
For better exposure it will be necessary to retract the thick mass of the sacrospinalis muscle, and this is easier if the lateral fibres are detached from the ilium these fibres can be recognized because they are on a deeper plane to the section of the muscle which arises mostly from the sacrum.

During this stage several perforating vessels will be found coming through the deep fascia and will need control, particularly those which pass downwards at the lateral margin of the sacrospinalis muscle into the superficial tissues of the buttock.



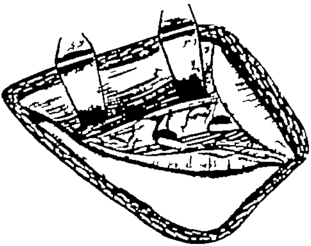
Deep dissection

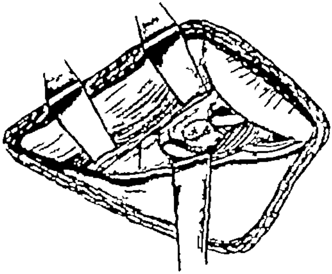
11 The further dissection is obliquely forwards and inwards. The middle layer of the lumbo-dorsal fascia together with the quadratus lumborum muscle is now detached from the transverse processes and from the inter-transverse ligaments and is retracted laterally after cutting the posterior attachment to the iliac crest here it will also be necessary to detach part of the iliac origin of the latissimus dorsi muscle. Small blood vessels to the muscles will need control. Beyond and deep to the quadratus lumborum muscle, the psoas muscle will gradually come into view

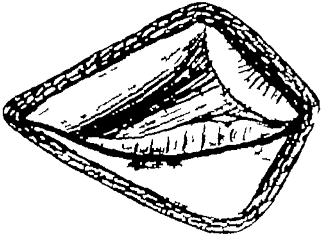


Exposure of the vertebral bodies

12 The intertransverse ligaments and muscles should now be excised, care being taken to preserve the posterior primary divisions of the lumbar nerves. Each transverse process is denuded by blunt dissection down to its base. The number of processes to be dealt with depends upon the purpose of the operation, but generally two should be cleared. The articular mass behind and medial to each transverse process will be exposed by sub-periosteal stripping so that the deepest muscles may be retracted from the base of the transverse process. Anteriorly the psoas muscle will be stripped from the transverse processes and gently retracted with a long bladed Langenbeck retractor Special care is now required to safeguard the lumbar nerve roots and vessels. These lie in a groove placed immediately below the base of the transverse process and directed obliquely downwards and forwards more markedly so in the last two intervals. They must now be kept constantly in view and, during the use of bone cutting instruments, must be protected by blunt dissectors.

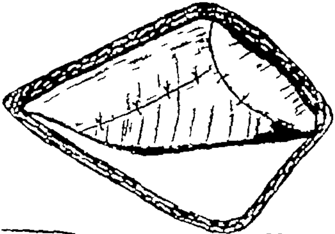






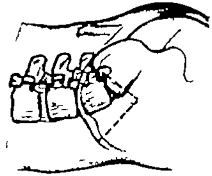
Excision of transverse process

13 The transverse process (or processes as the case may be) is excised with bone rongeurs and the removal of the basal section is facilitated by the use of a carefully directed gouge of appropriate small size (about ¼ inch in width) It is now possible to deepen the excavation and to direct the gouge either upwards or downwards and medially or anteriorly to enter the area of the lesion one wishes to treat.



Closure of wound

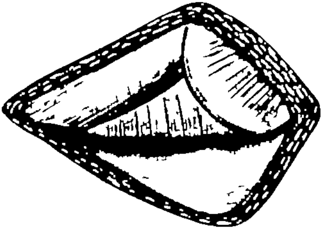
14 This is effected quite quickly after making certain of all potential bleeding points. The sacrospinalis muscle is replaced and its deeper fibres re-attached to the iliac crest. The quadratus lumborum muscle and deep lumbodorsal fascia are sutured to the under-surface of the sacrospinalis muscle as well as to the iliac crest and the latissimus dorsi muscle is similarly attached to the posterior sheath of the sacrospinalis muscle. The skin incision is closed in the usual way



VARIATION IN THE PROCEDURE
FOR EXPOSURE OF THE FIFTH
LUMBAR VERTEBRA

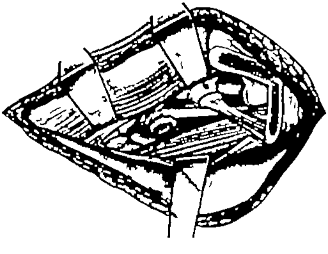
The incision

15 The only difference between this and the other incision is that the one used for this procedure must be sited at a lower level to extend farther on to the buttock.



Superficial dissection

16 This requires that a triangular section of the ilium should be removed. It should be about 2½ inches in width and should include the area from which the deeper portion of the sacrospinalis muscle and the quadratus lumborum has been reflected. The gluteal and iliacus muscles should be reflected downwards off the fragment of bone before it is removed. This makes possible the exposure of the ilio-lumbar ligament, a valuable guide to the transverse process of the fifth lumbar vertebra, the rest of the exposure of which resembles that already described.



POST-OPERATIVE CARE

LATERAL RHACHIOTOMY

After-treatment

Nursing is continued in a plaster shell supported upon a Bradford frame or similar apparatus raising the shell from the normal bed level The whole apparatus may well be slung beneath an overhead frame with counter-balancing weights making easier all nursing procedures and providing alterations in elevation of the patient. On the third day the patient is turned on to another frame the wound inspected and dressings adjusted. Stitches are removed upon the tenth day Streptomycin with P.A S or I.N.H is continued as the circumstances indicate. General treatment for the tuberculous disease is continued for a further period of approximately 8 months—re-education of the musculature of the lower extremities and abdomen is encouraged and mobilization of all limbs is progressed. After a suitable period further operative treatment is advisable, in most cases the affected areas of spine being arthrodesed by one of the bone grafting procedures as described under the title Spinal Fusion (page 100)

LATERAL EXPOSURE OF THE LUMBAR VERTEBRAE

After-treatment

This depends upon the purpose for which the operation has been done In tuberculosis it resembles that already described for dorsal rhachiotomy

[The illustrations for this Chapter on Lateral Rhachiotomy (Antero-lateral Decompression) have been prepared by Mr J Wheldon from original sketches by Mr Norman Capener]

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EVACUATION OF A TUBERCULOUS ILIAC ABSCESS

NORMAN CAPENER, F R C S

Consultant Orthopaedic Surgeon, Princess Elizabeth Orthopaedic Hospital and Royal Devon and Exeter Hospital, Exeter Mount Gold Orthopaedic Hospital Plymouth

PRE-OPERATIVE

Indications

A delaying factor in the recovery from tuberculous disease may be the formation of avascular masses of necrotic granulation tissue as caseous material or pus. Such abscesses may partially become absorbed or be shut off within calcified walls. They remain a debilitating influence through toxic absorption and as a reservoir of living tubercle bacilli. It has long been held that the evacuation of such abscesses was advisable during the active treatment of the disease. Incision and drainage has in the past been vitiated by the liability of the wounds to break down, leading to sinuses and secondary pyogenic infection. To mitigate these risks aspirations have been much used wide-bore needles being passed into the abscess through healthy skin at some distance from the summit of the swelling Such treatment may still be needed, particularly in the lumbar region. Nevertheless, because of the caseous nature of the pus, thorough evacuation may not be possible, and an open surgical approach is indicated. In the lumbar region abscesses track beneath the ilio-psoas fascia, and may travel far towards the surface at (1) the renal angle (2) through Petit s triangle (3) in the femoral triangle in front of the hip joint (4) laterally in front of the greater trochanter or (5) posteriorly in the buttock through the sciatic notch. An ilio-psoas abscess should be treated by aspiration or open evacuation above the crest of the ilium before it has reached any of these sites.

The general trend of progress will have been carefully studied based upon the patient s appearance, the subsidence of symptoms, the clinical signs of the disease and information gained from laboratory studies including the blood count, erythrocyte sedimentation rate, radiographic appearances and, of course the size and development of the abscess. If the disease is of recent onset, and therefore active, and the abscess is obvious clinically then it should be evacuated. Some surgeons advise that any active lesion with a paravertebral abscess even though it may be detected only in radiographs should similarly be dealt with. Nevertheless, where there is an abscess palpably near the surface it would be reasonable first to apply aspiration techniques but the surgeon should not hesitate to make an open approach if after 2 or 3 aspirations it is clear that the abscess is rapidly filling each time.

Before the operation the patient will have been nursed in a plaster shell and with the appropriate general constitutional care, including antibiotic drugs.

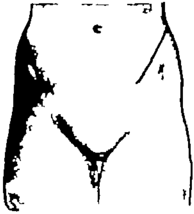
Position of patient

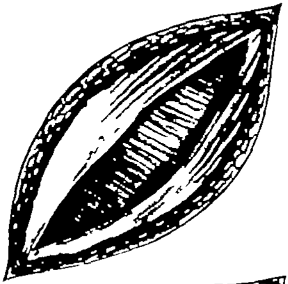
The patient will be turned out of the plaster shell and will lie in the dorsal recumbent position upon the operating table, which preferably should have facilities for lateral tilting

THE OPERATION

The incision

1 The incision follows the line of that used for nephrectomy in its lower portion. It starts about 1 inch above and medial to the anterior superior iliac spine and extends obliquely upwards and backwards for about 6 inches towards the renal angle. The incision is deepened to the muscular plane.

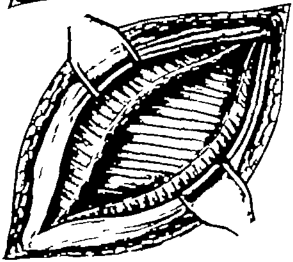




Division of muscles

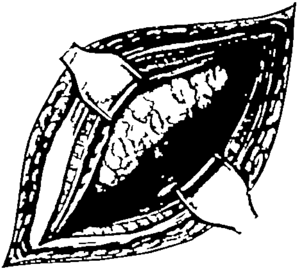
External oblique

2 The aponeurosis and muscular portions of the external oblique muscle are split in the direction of their fibres.



Internal oblique

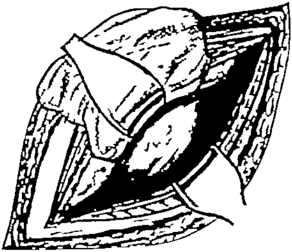
3 The fibres of the internal oblique are then divided in the line of the incision. At the lower end the transversalis muscle is split and in the posterior part of the incision its fibres are divided.



4

Positioning of extraperitoneal fat

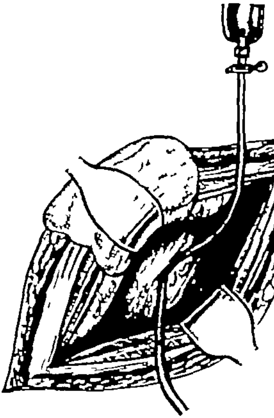
The extraperitoneal fat and peritoneum are then pushed medially under cover of an abdominal gauze pack. Deep in the wound laterally the iliacus muscle and its fascial covering will be recognized.



5

Exposure of abscess

With the help of a wide abdominal retractor the peritoneum is retracted medially and upwards until the characteristic bulging wall of the abscess is exposed. Further packs are inserted into the retroperitoneal space, especially at the pelvic brim, in order to limit soiling of the tissues. It is useful to tilt the operating table laterally so as to bring the surface wound into a dependent position for drainage during the next stage.



Evacuation of abscess

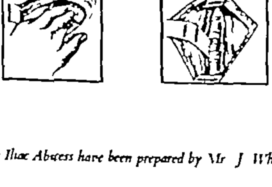
6 A stab wound is made into the abscess wall and a large-bore aspiration tube is inserted and suction applied. When all of the thin pus has been removed an irrigation tube is inserted and the cavity is washed out for a prolonged period with saline solution from a douche can. When it is thought that all caseous material has been removed 1 g of streptomycin is inserted into the cavity the opening into which should, when possible, be sutured.

Closure

Complete haemostasis having been secured, the gauze packs are removed and the peritoneum is allowed to fall back into place. The abdominal muscles are approximated and sutured in two layers. First the transversalis and internal oblique muscles are brought together with interrupted sutures of nylon or linen thread which include both groups of muscle fibres. The external oblique muscle is sutured separately No drainage is used.

Alternative method for high lumbar paravertebral abscess

The approach may be similar to that used for lumbar sympathectomy for the details of which see Volume 4 Part VII page 28



[The illustrations for this Chapter on Evacuation of a Tuberculous Iliac Abscess have been prepared by Mr J Wheldon from original sketches by Mr Norman Capener]

EXCISION OF NUCLEUS PULPOSUS OF LUMBAR INTERVERTEBRAL DISC

J R. ARMSTRONG, M.D., M CH. F R.C.S

Orthopaedic Surgeon to the Metropolitan and Lambeth Hospitals
Visiting Orthopaedic Surgeon to the Manor House Hospital London

PRE-OPERATIVE

Indications

The aim and purpose of operation in the treatment of a lumbar disc lesion is to remove completely all the nucleus pulposus of the affected disc, whether the nuclear tissue be displaced or not.

There are three indications for operation.

Failure of conservative treatment

The patient's symptoms may persist or recur in spite of adequate conservative treatment.

Massive nuclear retropulsion with cauda equina pressure

In the rare cases when a nuclear protrusion is sufficiently massive to produce cauda equina pressure, immediate operation is indicated if complete recovery is to be expected.

Severe and persistent interference with root function

When a root in its extrathecal course is compressed between a nuclear protrusion and bone so that its function is gravely disturbed, early operation is indicated to prevent irreversible root changes.

Special contra-indications

Only a relatively small proportion of all patients suffering from lumbar disc lesions require operative treatment. In particular operation is contra-indicated in the following circumstances.

Inadequate conservative treatment

Immediate operation is only necessary in the presence of cauda equina pressure or severe disturbance of root function. Otherwise operative treatment is not a matter of urgency and should never be undertaken until it is clear that conservative treatment in the form of rest and immobilization of the lumbar spine has been adequate and has failed to relieve the patient's symptoms.

Doubt in the diagnosis

A tentative exploration of the lower lumbar discs in patients with undiagnosed low back pain is usually an extremely unsatisfactory procedure. In obscure cases the possibility of the presence of some other condition, notably of tumour should be investigated carefully before operation.

Pre-operative preparation

Apart from the usual skin preparation, no special pre-operative measures are necessary

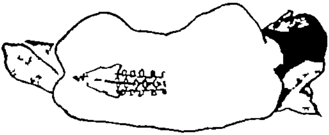
Anaesthesia

General anaesthesia with intratracheal intubation is satisfactory

THE OPERATION

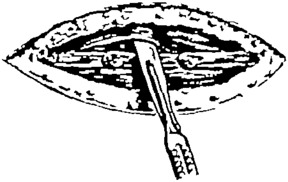
Position of patient and site of incision

1 The patient lies on the operating table in the lateral position, the spine, hips and knees being in full flexion. The side on which root symptoms are *most marked is uppermost*. The skin incision, vertical in the mid-line of the back, extends from just above the fourth lumbar spinous process downwards to just below the first sacral spinous process.



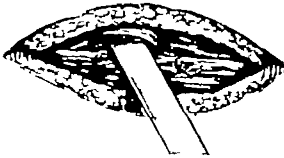
Division of muscles from the spine

2 When skin and subcutaneous tissue have been incised and retracted the erector spinae muscles are freed on both sides. Using a scalpel these muscles are cut from their attachments to the lateral surfaces of the spinous processes of the first sacral, fifth lumbar and fourth lumbar vertebrae, working from below upwards.



Separation of muscle layers

3 When the muscle layers have been cut from their attachment to the spinous processes they are stripped from the posterior surface of the sacrum and from the laminae of the fourth and fifth lumbar vertebrae with a broad-bladed osteotome. The osteotome is inserted along the side of the spinous processes and the muscles are then stripped outwards from the mid-line.



Packing of muscle layers to control haemorrhage

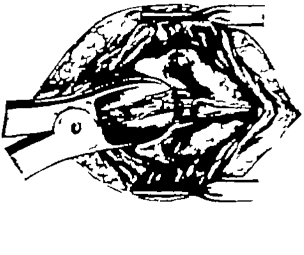
4 As the muscles are stripped from their bony attachments with the osteotome, swabs are packed in between the bone and the separated muscle layers to control haemorrhage. Stripping and packing is carried out alternately working from below upwards, and in this way little blood need be lost during this stage of the operation.

Exposure of laminae and ligamenta flava

5 When the stripping and packing has been completed on both sides along the whole length of the wound, the swabs are removed and a self-retaining retractor with deep blades is inserted and opened. The muscles are drawn aside by the retractor and the posterior surface of the laminae of the fourth and fifth lumbar vertebrae and the posterior surface of the sacrum is exposed, together with the ligamenta flava at the L.4/L.5 and L.5/S.1 levels.

Division of interspinous ligament and removal of spinous process

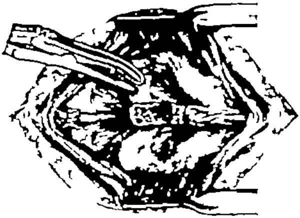
6 The interspinous ligament between the spinous process of the fourth and fifth lumbar vertebrae is divided close to the fourth lumbar process with a scalpel. The ligament between the fifth lumbar and first sacral processes is similarly divided at its attachment to the first sacral process. The spinous process of the fifth lumbar vertebra is then removed, using a double-action bone cutter



7

Removal of half of the vertebral lamina

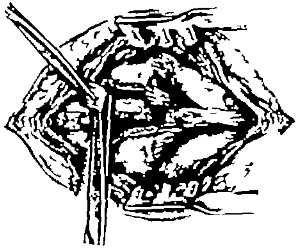
Removal of the fifth lumbar spinous process provides easy access to the back of the fifth lumbar lamina. Using double-action bone nibblers the uppermost half of this lamina is removed piecemeal, working from below upwards.



8

Removal of ligamentum flavum

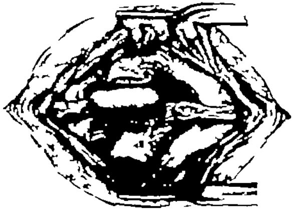
When the upper half of the fifth lumbar lamina has been removed, the free edges of the ligamentum flavum above and below are picked up with forceps and the ligaments are cut away with a pair of scissors, so that the upper half of the spinal canal is opened between the fourth lumbar lamina and the top of the sacrum.



9

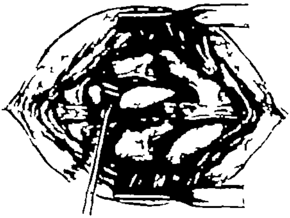
Exposure of spinal theca

When the hemilaminectomy has been completed and the ligamenta flava removed, the theca will be found to be covered with a little loose extrathecal fat and areolar tissue. Using a blunt dissector this is gently separated until the theca itself is completely exposed along the whole length of the opening into the spinal canal.



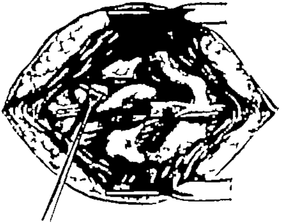
Exposure of first sacral nerve root in its extrathecal course

10 The exposed theca is gently retracted towards the mid-line immediately below the cut end of the fifth lumbar lamina. When the theca has been so retracted the first sacral root will be found surrounded by extrathecal fat on the anterior wall of the spinal canal. The course of this root is downwards and slightly outwards across the anterior wall of the canal from its point of emergence from the theca opposite the body of the fourth lumbar vertebra.



Exposure of the L.5/S 1 intervertebral disc

11 When the first sacral root has been exposed and cleared by blunt dissection, the root itself is gently retracted medialwards and lying immediately below the root the posterior surface of the L.5/S.1 intervertebral disc is identified. The posterior surface of the disc is covered by some extrathecal fat and by the anterior plexus of the intraspinal extrathecal veins which run vertically upwards over the lateral part of the disc surface. If a nuclear protrusion is present identification of the disc is much easier but in these circumstances the root may be stretched over or even adherent to the protrusion, and must be separated and retracted with great care.

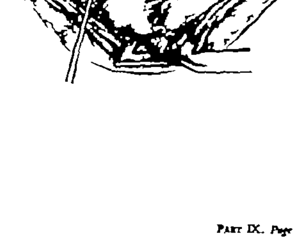


Exposure of fifth lumbar nerve root and L.4/L.5 intervertebral disc

12 The L.4/L.5 disc lies at a higher level, being situated immediately below the lower edge of the fourth lumbar lamina. The theca is retracted medialwards at this level and the fifth lumbar root is identified in its extrathecal course and similarly retracted, thereby exposing the L.4/L.5 disc. The posterior surface of the disc can then be cleared and identified. If a nuclear protrusion is present at this level the fifth lumbar root may be stretched over or adherent to this protrusion, and again great care must be exercised in separating the root and retracting it medially

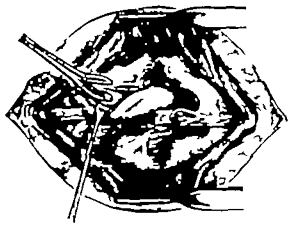
Incision of annulus fibrosus

13 The posterior surface of the intervertebral disc having been exposed and cleared the presence of a disc lesion can be detected. If a nuclear protrusion is present such a lesion is obvious, the tumour formed by the protrusion being both palpable and visible. If the lesion is of the degenerate type without nuclear protrusion its presence can only be revealed by careful palpation of the surface of the disc with a blunt dissector when the presence of such a lesion is shown by a softened area of annulus. A lesion having been detected, the annulus is incised in a circular manner a fairly large piece being removed to allow easy access to the interior of the disc.



Removal of nucleus pulposus

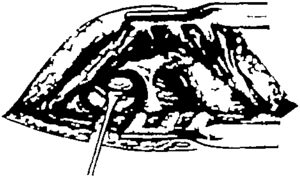
14 As the annulus is incised, the nucleus of a degenerate disc often extrudes more or less spontaneously. When the annulus has been opened completely the whole of the nucleus is removed with punch forceps. Quite often large nuclear sequestra can be picked out with these forceps without any difficulty but the removal of the loose sequestra alone is not enough, the entire nucleus must be removed. To do this various sizes of punch forceps are employed, and angled forceps are used to reach nuclear tissue in the unexposed half of the disc. Some surgeons complete the nuclear removal by curettage, using a small sharp spoon.



ALTERNATIVE PROCEDURE—INTER-LAMINAR OR "FENESTRATION" APPROACH

Exposure of L.5/S 1 disc

15 Some surgeons use a much more restricted approach to the intervertebral disc. By this method the muscles of one side of the spinous processes only are divided and retracted away from the mid-line. The spinous processes themselves are left intact, and only the posterior surface of half of the fifth lumbar lamina with the ligamentum flavum above and below is exposed. The discs are approached by opening the spinal canal between the laminae by removing the ligamentum flavum, and the laminae themselves are not removed although they may be nibbled away a little to allow better access. Only one disc at a time can be exposed, the L.4/L.5 disc by removing the ligamentum between the fourth and fifth lumbar laminae and the L.5/S 1 disc by removing the ligamentum between the fifth lumbar lamina and the sacrum. The inter-laminar approach may be duplicated at as many levels as may be necessary but the exposure of each individual disc is limited.



Muscle and skin closure

16 The muscles, fascia and skin are closed in layers with interrupted sutures. A firm pressure dressing is applied over the wound, and the patient is returned to the ward in bed.

SPECIAL POST-OPERATIVE CARE

The disc is an integral part of an intervertebral joint and removal of its nucleus disorganizes this joint permanently. Successful healing depends on the formation of a stable fibrous ankylosis of the damaged joint, and this fact dominates the after-treatment.

Ankylosis is a slow process, taking place over a period of several months. During this time the lumbar spine must be protected from movement and from mechanical strains. This is particularly important in the early stages after operation, and inadequate protection is often associated with an irritable joint and persistent low back pain.

For three weeks following operation the patient is nursed flat in bed. One small pillow only is allowed, and although the patient may turn on his side or face if he wishes, flexion of the lumbar spine is avoided. The dressing is changed on the fifth day and the skin sutures removed about the tenth day after operation.

Three weeks after operation the patient is allowed to get out of bed and to walk and sit, wearing a lumbar corset with incorporated Goldthwait steels. Activity is gradually increased and the patient is usually fit to return home about four weeks after operation.

During the next three or four months a lumbar corset is worn at all times during the day. Normal activity is gradually resumed, but flexion of and flexion strains on the lumbar spine, that is stooping and lifting, should be avoided completely.

[*The illustrations for this Chapter on Excision of Nucleus Pulposus of Lumbar Intervertebral Disc were drawn by Miss Joan Fairfax Whiteside.*]

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SPINAL FUSION
THORACIC AND LUMBAR

P H. NEWMAN, *D S O., M C.*, F.R.C.S

Orthopaedic Surgeon to the Middlesex Hospital and the Royal National Orthopaedic Hospital London

PRE-OPERATIVE

GENERAL PRINCIPLES

Indications

Arthrodesis in the vertebral column is a valuable surgical treatment in the prevention of increasing deformity in maintaining correction of deformity and in stabilizing diseased, unstable or degenerated segments.

It is indicated in some patients with idiopathic or paralytic scoliosis, in localized foci of healing tuberculosis, occasionally for instability associated with severe ligamentous or disc injury disc degeneration and spondylolisthesis, and rarely in patients with severe pain arising from old bony injury or marked degenerative changes in the intervertebral joints.

Although it is a major surgical procedure it is comparatively safe, bearing a mortality rate of one or two per thousand fusions, but owing to the long post-operative period of recumbency it is contra-indicated in the aged or in patients with chest or cardiac disease.

Pre-operative preparation

A plaster bed is made with the patient lying prone. A posture of hyperlordosis, which will predispose to post operative abdominal distension and pressure sores in the lumbar area, should be avoided by placing a pad under each anterior superior spine.

The plaster bed is cut, trimmed, dried and mounted on wood to raise it from the bed level for nursing purposes.

It is important that the patient spend 7 days in the bed before operation and during this period an anterior shell is made for turning

Skin preparation is important, but towelling, especially if the anus is enclosed, may be more dangerous than beneficial. Should any difficulty be likely to arise of recognizing the level of the lesion at operation the area should be accurately marked radiographically

Anaesthesia

General anaesthesia administered through an endotracheal tube is essential.

Frequently fusion is a lengthy surgical procedure and may be accompanied by considerable blood loss, therefore facilities for blood transfusion must be available

Position on the table

Depending upon the nature of the pathological lesion the patient may remain in the plaster bed during operation or lie free on the table Preferably the patient is free lying with the *anterior superior spines immediately over the* break of the table to allow for flexion and extension under observation. To facilitate breathing and to prevent pressure on the abdominal great veins the patient lies on two long thin bolsters placed down either side from the chest to the thighs.

FUSION OF THORACIC AND LUMBAR SEGMENTS

Indications

Tuberculous disease, painful post-traumatic lesions, paralytic, congenital or idiopathic scoliosis, and various other uncommon conditions are all occasional indications for arthrodesis. The selection of individual cases among these groups who will most benefit by spinal fusion is sometimes a difficult problem requiring considerable experience

Contra-indications

Extensive fusion of the spine is a major surgical procedure and may have to be performed in more than one stage. It should not be performed for active tuberculosis. Care must be taken with patients recumbent for long periods. Active chest disease a low vital capacity or heart disease are contra-indications.

Anaesthesia

General anaesthesia with an endotracheal tube is routine. Drugs producing hypotension may be valuable in decreasing blood loss and cutting down operative time.

BODY TO BODY FUSION—LUMBO-SACRAL JUNCTION

During the past 20 years various operations have been described for fusing one vertebral body to another In the lower lumbar region the vertebral bodies can be approached anteriorly through a transperitoneal route or posteriorly by total or partial removal of laminae and facets and retraction of the dura and nerve roots medially

Either method is a formidable surgical procedure and results so far published do not warrant their recommendation as routine operations.

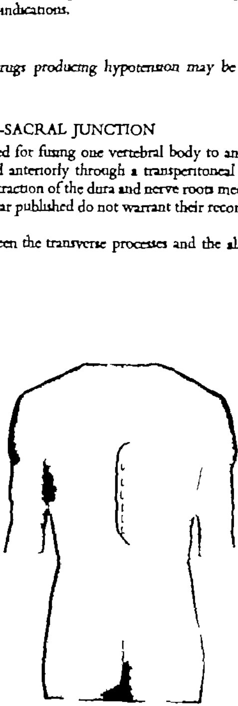
More recently fusion has been attempted by grafts placed between the transverse processes and the alae of the sacrum, but long-term results are not yet available.

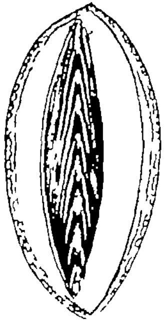
THE OPERATION

POSTERIOR FUSION OF THORACIC AND UPPER LUMBAR SEGMENTS

The incision

1 The incision extends slightly to one side of the midline and curves at its extremities to the opposite side to include as many segments as are required to be fixed

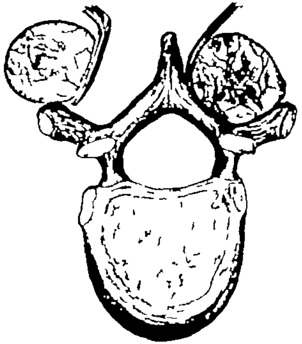




2

Freeing of supraspinous ligament

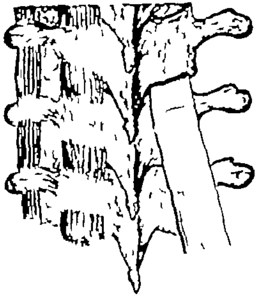
The incision is deepened. Severe subcutaneous bleeding is controlled best by a series of small curved artery forceps (Dunhill's) clamped to the deep fascia. The supraspinous ligament is split in the midline and dissected free of the spinous processes, with care to leave it intact at the segments adjoining the area to be grafted.



3

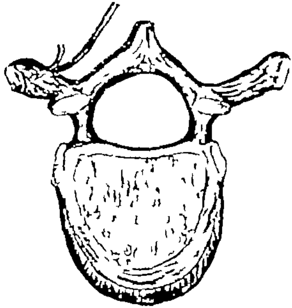
Stripping of muscles from spinous processes

With an osteotome the muscles are stripped subperiosteally from the spinous processes, laminae, articular facets and transverse processes. They are parted with self-retaining retractors.



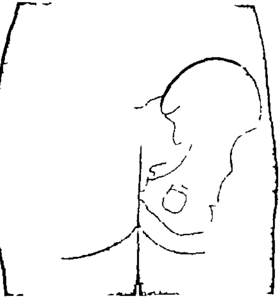
Clearing of cartilage from articular surfaces

4 The joints are cleared of their capsules and the cartilage is erased from each articular surface with a small thin, curved osteotome, measuring $\frac{1}{4}$–$\frac{1}{2}$ inch in width. Additional thin layers of bone are cut from each surface and allowed to fill the joint space.



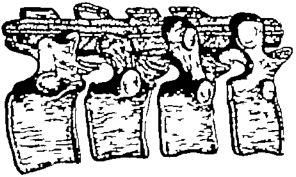
Bone decortication

5 The tips of the spinous processes are removed and preserved for bone chips. All exposed bone must be thoroughly cleaned from ligaments and muscle attachments. The dorsal surface of the bases of the spinous processes, the laminae, the facets and the articular processes are decorticated and the bone slivers that are erased bent downwards or upwards to cross those from adjacent laminae.



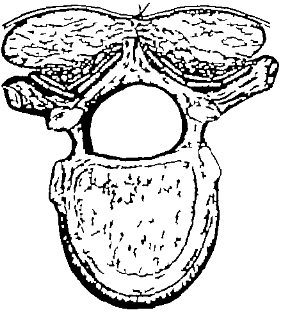
Removal of bone from iliac crest

6 Additional bone is taken from the ilium. An incision is made around the crest over its posterior half and bone is removed, preferably in thin plates. Additional pieces can be used by cutting them into chips.



Insertion of bone fragments

7 Small slivers are packed firmly into the spaces of the excised joints the larger fragments are laid on the laminae parallel to the axis of the spine overlapping and pressed well down with a large punch. Bone chips are used to fill up any gaps. Grafts applied to the ninth–twelfth thoracic vertebrae are illustrated.



Suture of lumbo-dorsal fascia

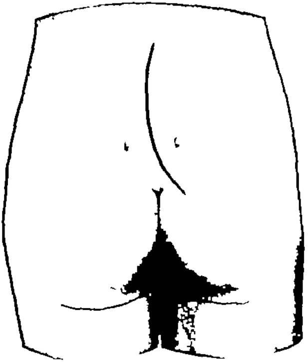
8 The lumbo-dorsal fascia is sutured across the midline replacing the muscle groups in their correct position. Great care must be given to haemostasis before closing the wound, and no dead space should be left to encourage the formation of a haematoma.

Closure of the wound is completed with interrupted subcutaneous and cutaneous sutures.

POSTERIOR FUSION AT LUMBO-SACRAL JUNCTION

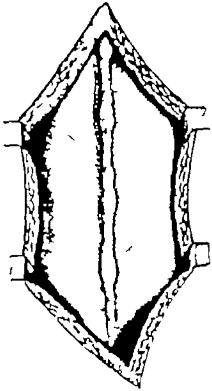
Incision

9 The skin incision extends from the spine of the third lumbar vertebra to a point 1½ inches below the right posterior superior iliac spine gently curving to the right in a shallow reversed J avoiding the upper limit of the natal cleft.



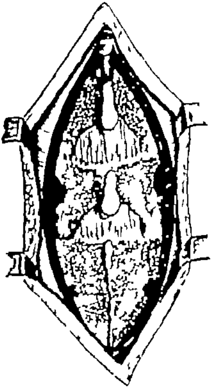
Exposure

10 The tips of the spinous processes and the lumbo-dorsal fascia are exposed by reflecting the skin and fat on either side.
The lumbo-dorsal fascia is incised vertically slightly to one side of the midline. The median raphe (supraspinous ligament) is carefully dissected from the tips of the spinous processes to be left continuous with the fascia on the opposite side. The median raphe proximal to the spine of the fourth lumbar spinous process is left intact, to avoid a potential weakness above the level of the graft.



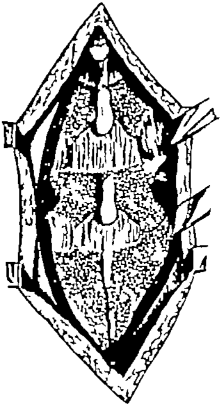
Stripping of spinous processes

11 The spinous processes and laminae are stripped subperiosteally with a 1-inch osteotome. Care is taken, in the presence of spina bifida occulta, especially of the sacrum, not to penetrate the fibrous gap. The muscle masses are separated with strong self-retaining retractors such as those of Adson.



Decortication of laminae

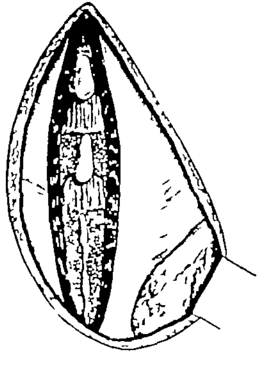
12 Further dissection is needed to clean the laminae spinous processes and articular facets. The laminae are decorticated.



Clearing of articular surfaces

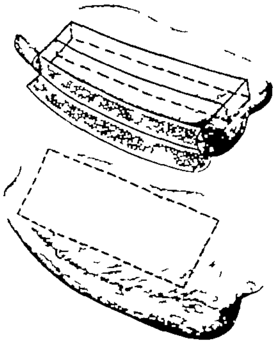
13 Exposure of the intervertebral joints is facilitated by additional retraction given by a rugine (Bristow type) thrust lateral to the superior facets to rest on the base of the transverse process.

The capsule is removed and the adjoining articular surfaces are denuded of cartilage with a curved osteotome. The bed for the graft is now ready



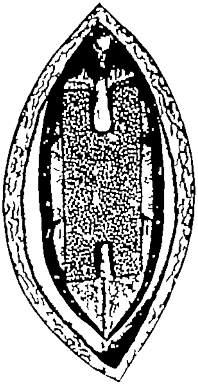
Exposure of ilium

14 The posterior superior spine and the crest of the ilium are exposed by further reflection of the skin flap



15 **Removal of bone from the ilium**

The crest of the ilium is undercut laterally prised up and hinged medially Appropriate grafts (see above) consisting of lateral cortex and medullary bone are cut as required. Additional medullary slivers and chips are taken. The interarticular joints are tightly packed with bone chips.



16 **The Bosworth "H graft**

For the Bosworth "clothes-pin graft the adjacent borders of the fourth lumbar and first sacral spinous processes are undercut and that of the fifth lumbar is removed.

The graft is fashioned to be slipped in with the spine in flexion and locked by moderate extension.

Fremont Chandler graft

17 The bases of the fourth lumbar and second sacral spinous processes are pierced with a curved awl and wire, gauge 20 or 22 is threaded through.

Two longitudinal grafts are fitted to the laminae extending down to S. 3

Two transverse grafts are fashioned to fit between the spinous processes and lie posterior to the longitudinal grafts.

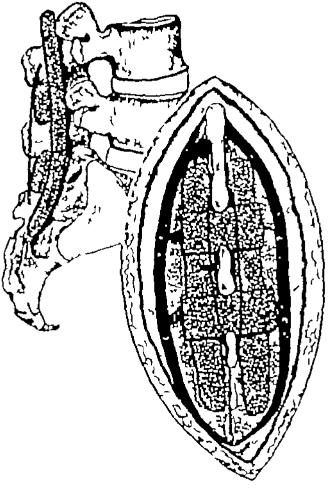
The wire is secured and tightened with the spine postured in moderate extension.

Bone slivers and chips are fitted round the sides of the longitudinal grafts and the whole mass firmly compressed with a broad punch.

Careful haemostasis is essential before closing the wound.

The masses of the erector spinae are approximated by three loose enveloping sutures. The lumbo-dorsal fascia which has two distinct layers is sutured over the tips of the spinous processes to reconstitute the supraspinous ligament. The crest of the ilium is replaced and the gluteal fascia sutured to the lumbo-dorsal fascia.

Interrupted subcutaneous and skin sutures finish the repair of the wound.



POST-OPERATIVE CARE AND COMPLICATIONS

A thin gauze dressing, strapped in position, is all that is necessary in the plaster bed. Haemostatic pressure is assured by the supine position.

Complications

Retention of urine and abdominal distension are both liable to occur during the first 2 or 3 days after operation. For retention, catheterization may be necessary the head of the bed is raised and 1 ml. carbachol administered. The degree of abdominal distension is seldom severe and often can be relieved by giving tincture of opium and belladonna orally Rarely acute dilatation occurs and gastric suction may be necessary

Management of patient

The patient is turned on the third day and the back is carefully inspected and treated for pressure points the wound is dressed. The frequency of turning will be determined by necessity but usually once weekly should be sufficient.

The patient remains in the plaster bed for 3 months, followed by an ambulatory period in a plaster or plastic jacket.

[*The illustrations for this Chapter on Spinal Fusion Thoracic and Lumbar were drawn by Mr F Price*]

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OPEN REDUCTION AND PLATING OF FRACTURE-DISLOCATION OF THE SPINE

E. W Meurig Williams, O St J., B.Sc., M.B., B.Ch., M.R.C.S., L.R.C.P

Consultant Orthopaedic Surgeon Prince of Wales Orthopaedic Hospital Cardiff Welsh Regional Hospital Board

PRE-OPERATIVE

Indications

Fracture-dislocation of the spine commonly occurs at the thoraco-lumbar junction and is the result of a hyper flexion injury There is a "slice" fracture of the vertebral body with dislocation of the posterior articulations of the intervertebral joint, locking of the facets and rupture of the posterior ligaments. The spinal cord and cauda equina are crushed, causing paraplegia. The objects of the operation are to reduce the dislocation and so decompress the spinal cord and cauda equina to stabilize the spine by plating so as to maintain the reduced position, thus alleviating pain and to enable the patient to be properly nursed in order to eliminate bed sores.

Special contra-indications

Occasionally this injury is complicated by rupture of the diaphragm, which is usually obvious on x-ray examination of the chest. In this case treatment of the chest injury must take precedence over immediate operative treatment of the spinal injury

Pre-operative preparation

The operation must be regarded as an emergency Radiological examination, including the chest, must be carried out. The patient should have been transported from the scene of the accident lying in the prone position with a pillow beneath the chest, thus gently extending the spine. If the patient is lying on his back he should be turned immediately to the prone position, thereby using the intact anterior common ligament as a splint and therefore alleviating pain and preventing further damage. The skin of the back should be cleansed with Cetavlon. As there may be considerable blood loss from the large haematoma, preparations should be made to give a blood transfusion.

Anaesthesia

General anaesthesia with an endotracheal tube is essential.

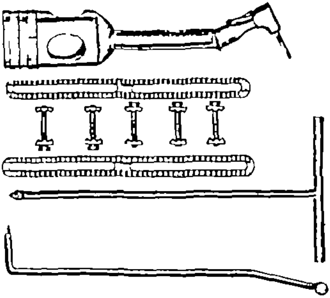
Alternative procedures

This injury is sometimes complicated by fracture of the spinous processes, laminae or pedicles, and there may be one or several loose fragments of bone either penetrating the spinal cord and cauda equina or pressing on them These fragments should be excised. If a spinous process only is fractured, this may be left in situ.

There are occasions when the bone damage is so extensive that it is impossible to anchor the plates in position. In this case loose bony fragments are excised, closure is carried out and the patient is nursed on a Stryker frame

THE OPERATION

Special equipment and apparatus



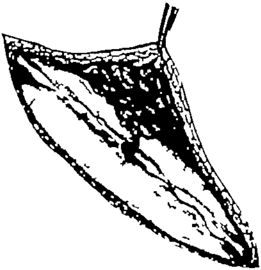
1 The Meurig Williams spinal plates are serrated and slotted, so as to allow each bolt to be anchored through bone and therefore prevent the plates cutting out. The serrations on the washers match the serrations on the plates, but only the washer for the tip of the bolt is threaded. When the bolt is tightened washers and plates become effectively locked. A right-angled drill attachment to the Luck bone saw is used for boring the holes through the spinous processes, and the holes are enlarged with the right-angled trocar-pointed awl. It is necessary to use an operating table that can be angled.

Position of patient

2 The patient is placed on the operating table in the prone position, with the table angled at the site of the fracture-dislocation. A rubber wedge cushion is placed beneath the shins to prevent prolonged forcible plantar-flexion of the feet and pressure on the toes. The arms are carried above the head. The skin is prepared and towelling is carried out in the usual way.

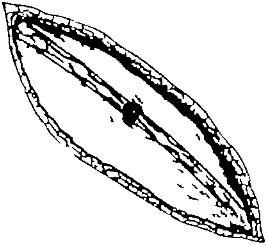
The incision

3 The vertebral spines are palpated and the gap between the spinous processes where the ligaments are ruptured is easily felt. The incision *should* be 8 *inches* long over the vertebral spines, and centred over this gap.



Clearing of haematoma

4 The wound is deepened through the subcutaneous fat and bleeding points are secured with artery forceps, exposing a large haematoma. This is cleared away to expose the ruptured supra-spinous and inter-spinous ligaments.

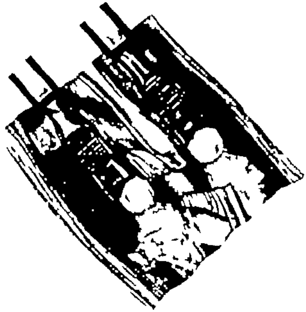


Incision of lumbar fascia

5 The lumbar fascia is then incised on either side of the vertebral spines throughout the whole length of the wound.

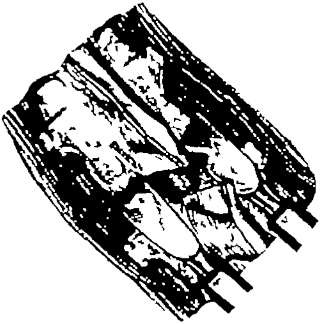
Exposure of vertebrae

6 A large osteotome is used to detach the spinal muscles to expose spinous processes, laminae and posterior intervertebral joints. This must be done carefully starting from above downwards and from below upwards. In the depths of the centre of the wound the ligamentum flavum will be found to be ruptured exposing the dura, and the glistening ... scular facets of the vertebra below t ... ation will be obvious. Haemorrhage ... lled with the sucker and by packing ... c- tors are then inserted



Insertion of periosteal elevators

7 When the spinous processes and laminae have been cleared of muscle the tips of two slightly curved periosteal elevators are hooked very carefully underneath the lower borders of the inferior articular facets of the vertebra above the dislocation.

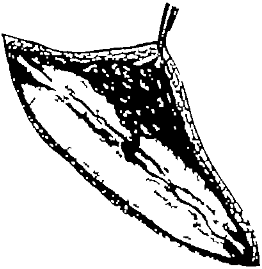


Reduction of dislocation

8 These articular facets are then lifted over the superior articular facets of the vertebra below in the manner shown thus reducing the dislocation

Reversion to horizontal

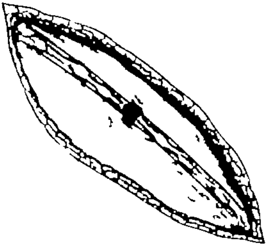
9 The table is then straightened to the horizontal position. It is important not to hyper-extend the spine. Plating should be carried out in the neutral position, otherwise there will be a tendency later for the bolts to cut out.



4

Clearing of haematoma

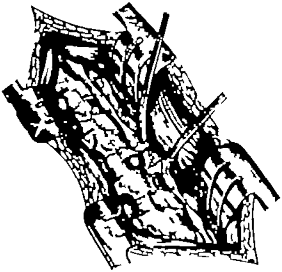
The wound is deepened through the subcutaneous fat and bleeding points are secured with artery forceps, exposing a large haematoma. This is cleared away to expose the ruptured supra-spinous and inter-spinous ligaments.



5

Incision of lumbar fascia

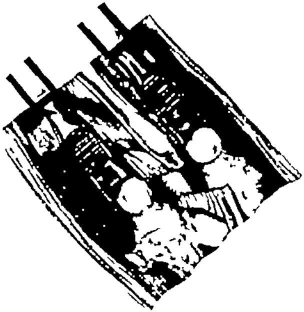
The lumbar fascia is then incised on either side of the vertebral spines throughout the whole length of the wound.



6

Exposure of vertebrae

A large osteotome is used to detach the spinal muscles to expose spinous processes, laminae and posterior intervertebral joints. This must be done carefully starting from above downwards and from below upwards. In the depths of the centre of the wound the ligamentum flavum will be found to be ruptured exposing the dura and the glistening white articular facets of the vertebra below the dislocation will be obvious. Haemorrhage is controlled with the sucker and by packing. Spinal retractors are then inserted.



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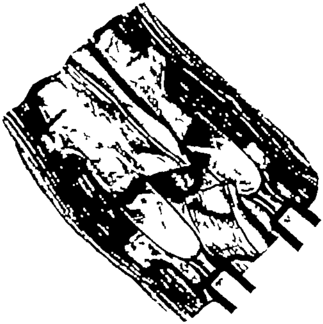

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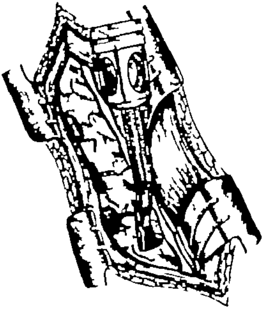
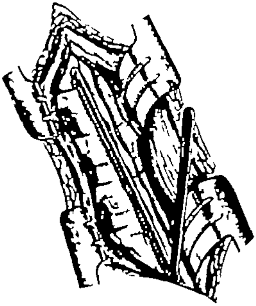


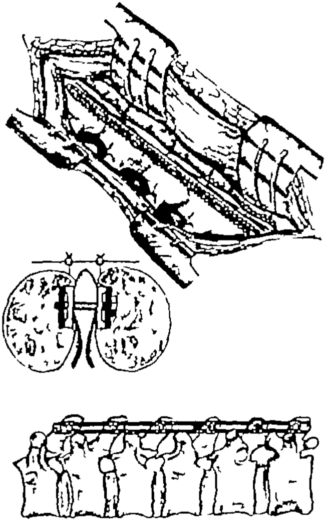
Drilling of spinous process

10 The right-angled drill attachment to the Luck bone saw is used to drill the hole for the passage of the bolt through the spinous process, and the hole is enlarged with the right angled trocar-pointed awl.



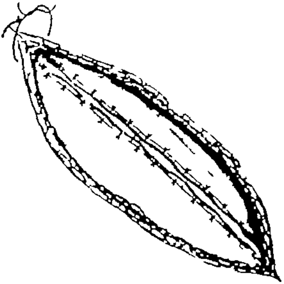
Fixation of plates

11 The plates are placed in position and can be steadied with Lane's tissue forceps or lion bone holding forceps. The lowest bolt and washers are then applied and the bolt is tightened with a spanner. The top bolt is inserted next in a similar fashion, followed by the remaining three or four.



Completed fixation

12 *It is usually necessary to plate only the affected* vertebra and two vertebrae above and two vertebrae below. Sometimes, however, owing to fractures of spinous processes, it is wiser to fix 6 spinous processes together as shown in order to obtain adequate fixation.



Wound closure

13 At this stage the wound is usually dry but any bleeding points may now be tied. The lumbar fascia is closed with interrupted catgut sutures on either side of the spinous process. The skin is *approximated with interrupted* nylon sutures.

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Transfusion of blood is commenced in the operating theatre and completed after the patient has returned to the ward.

Sedation is seldom necessary after the first 24 hours following operation, because there is almost complete relief from pain. The wound heals well and the skin stitches are removed after 12–14 days. If even the slightest evidence of wound inflammation appears, systemic penicillin should be given.

Nursing

Pillow nursing on an ordinary bed is instituted immediately. The patient is nursed propped on his side, with a pillow between the legs and with the feet supported at right angles. *He is turned on to the other side every two hours—twelve times in the 24 hour period.* Turning, together with normal skin toilet with soap and water, is all that is necessary to prevent pressure sores.

Care of the bladder

Intermittent catheterization (twice a day), using a soft rubber catheter and employing the strictest possible no-touch technique, should be carried out. Automatic action of the bladder is often established in 3–4 weeks.

Care of the bowels

Manual extraction of faeces is the best way of dealing with this problem. The patient is instructed and trained in this procedure as soon as possible after the operation.

Physiotherapy

It is essential that a full range of movements be maintained in all joints of both lower limbs and therefore each joint is put through a full range of movements by the physiotherapist at least once a day, commencing on the day after operation. Exercises aimed at developing the musculature of the arms are also carried out.

[The illustrations for this Chapter on Open Reduction and Plating of Fracture Dislocation of the Spine were drawn by Mr J Whieldon.]

Bibliography

Holdsworth, F. W. (1956). "Traumatic Paraplegia." In *Modern Trends in Orthopaedics*, 2nd Series. London: Butterworth.
— and Hardy, A. (1953). "Early Treatment of Paraplegia from Fractures of the Thoraco-lumbar Spine." *J. Bone Jt Surg.*, 35B, 540.
Williams, M. (1956). *Spinal Plates*, p. 50. Bridgend: Zimmer.

SACRO-ILIAC FUSION

P H. Newman D S O., M.C., F.R.C.S.

Orthopaedic Surgeon to the Middlesex Hospital and the Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

The indications for arthrodesis of the sacro-iliac joint are few examples being tuberculosis and severe pain associated with post-traumatic instability and degenerative change.

For tuberculosis the extra-articular method will be preferable.

Contra-indications

A generation ago intra-articular arthrodesis was frequently performed for chronic sacro-iliac strain or degenerative arthritis. It is certain now that the diagnosis was often at fault, being mistaken for derangement of the lumbo-sacral or other lower lumbar joints.

Arthrodesis for tuberculosis should not be undertaken in the acute stage when the affected area of the bone and soft tissue is poorly defined.

Clinical and radiological examination of the chest must exclude active pulmonary disease.

Pre-operative preparation

A plaster bed extending from the base of the neck to mid-calf is made with the patient lying prone. It is trimmed and mounted but not padded such padding does not increase the efficiency or the comfort of a well made plaster bed. The patient spends 7 days in the bed before operation and during this period an anterior shell, for turning purposes, is made.

Skin preparation is important, but towelling which includes the anus may predispose to infection.

Position on table

The patient assumes a prone position in the anterior plaster shell.

An intratracheal tube for anaesthetic administration is essential.

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Skin preparation is important, but towelling which includes the anus may predispose to infection.

Position on table

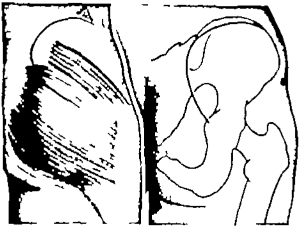
The patient assumes a prone position in the anterior plaster shell.

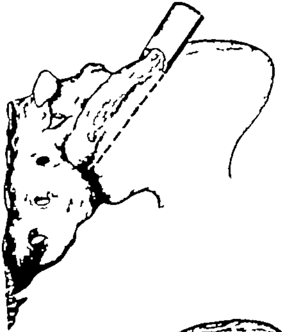
An intratracheal tube for anaesthetic administration is essential.

THE OPERATION

The incision

1 The incision passes medially along the posterior half to one-third of the outer lip of the iliac crest, curving downwards and then laterally around the posterior superior and inferior spines and extending farther if required to follow the direction of the fibres of the gluteus maximus.





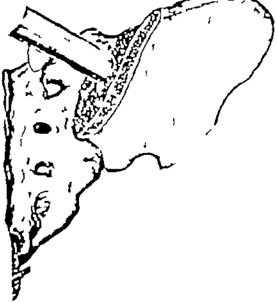
EXTRA-ARTICULAR ARTHRODESIS

Exposure

2 The incision is deepened to bone, the periosteum incised and the posterior third of the crest and the posterior superior spine cleaned. With a chisel this part of the bone is undercut and removed, wrapped in a saline swab and preserved for future use

Curetting of cavity

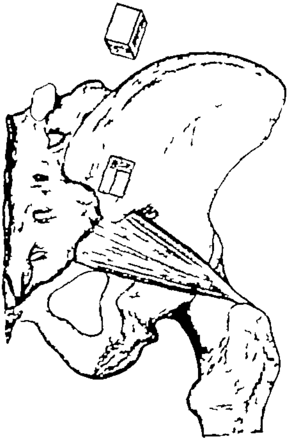
3 In operating for tuberculosis the abscess cavity will now probably have been opened, and this is thoroughly curetted with a spoon. Great care must be taken not to penetrate beyond the limits of the cavity



Bone decortication

4 The adjoining part of the medial aspect of the ilium and the ala of the sacrum is decorticated. Chips are made from the bone removed and an additional supply can be obtained from the ilium.

The cavity and space between ilium and sacrum is packed with chips and compressed with a large punch.



INTRA ARTICULAR ARTHRODESIS (SMITH-PETERSEN)

Removal of bone block

5 The posterior half of the crest is cleaned and the mass of gluteal muscles reflected and retracted downwards to expose the outer table of the ilium below the *posterior superior* spine. Care is taken not to injure the superior gluteal vessels as they emerge above the piriformis muscle.

A line drawn from the lower tip of the posterior superior spine and the top of the great sciatic notch gives the lower extremity of the joint. From this base line and 1 inch lateral to the spine an oblong block of bone 1 inch × ' inch is removed.

The cartilage of the joint is exposed and removed from both surfaces the block of bone is then punched back with additional bone chips if necessary

[The illustrations for this Chapter on Sacro-Iliac Fusion were drawn by Mr F Price]

STABILIZATION OF THE ACROMIO-CLAVICULAR JOINT

G L W BONNEY MS FRCS

Consultant Orthopaedic Surgeon to St Mary's Hospital and Paddington Green Hospital London Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls Research Assistant to the Institute of Orthopaedics London

PRE-OPERATIVE

Indications

This operation is indicated where there is complete dislocation of the acromio-clavicular joint and in the event of

(1) Failure of methods of closed reduction and immobilization, when for any reason it is important to restore the contour of the shoulder and the stability of the shoulder girdle.

(2) Impairment of stability of the shoulder girdle by extensive ligamentous damage.

Special contra-indications

This operation should not be undertaken as a routine procedure for acromio-clavicular dislocation, for it is often the case that complete and unreduced dislocation causes little impairment of function.

Pre-operative preparation

It should be established that movements of the shoulder joint are full before operation is undertaken.

Anaesthesia

General anaesthesia is necessary and administration by endotracheal tube facilitates towelling and approach

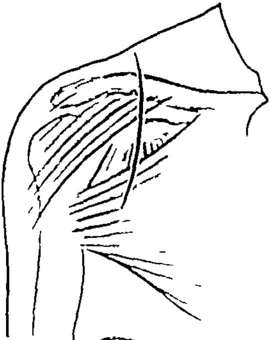
Position of patient

The patient lies on his back, the affected shoulder being raised by a sand-bag placed behind it. The skin of the shoulder area, of the axilla and of the related part of the neck is prepared. The head is towelled as in operations on the thyroid, and towels are placed to cover the body The arm is separately towelled so that it can be manipulated as necessary during the operations. The outer side of the thigh of the opposite side is also prepared and suitably towelled.

THE OPERATION

The incision

1 The incision is of the "sabre cut" type, in the para-sagittal plane of the tip of the coracoid process, extending from behind the postero-superior border of the clavicle to about 2 inches below the coracoid process.



Exposure of coracoid process

2 Both flaps are undercut to expose the clavicle and the delto-pectoral groove. The latter is opened to expose the coracoid process.

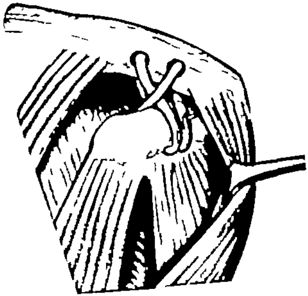
The clavicle is cleared for a length of about 3 cm. at a point directly above the coracoid process. The coracoid process itself is now cleared and a passage is made by blunt dissection below the angle of the process, the muscular attachments being left undisturbed.

The procedure for repair

During the first part of the operation an assistant cuts from the thigh a strip of fascia lata $\frac{1}{4}$ inch in width and 8 inches in length.

Drilling of holes in clavicle threading of fascia

3 The fascial graft is used to make a sling between the clavicle and the coracoid process. To this end, two holes are made with a $\frac{3}{32}$ inch drill in an antero-posterior direction through the prepared part of the clavicle, separated from each other by about $\frac{3}{4}$ inch. The fascial strip is now taken and inserted into the tunnel formed below the coracoid process. Each end is drawn up through each of the holes in the clavicle, brought forward, crossed in front, and brought again below the coracoid.

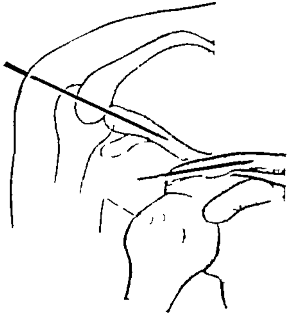


Suture of fascial ends

4 The ends of the fascial graft are sutured with silk to each other and to the related parts of the graft. The repair can be reinforced by sutures placed between the fascial graft and the remains of the coraco-clavicular ligament.

Internal fixation

5 In order to protect the fascial graft during the first three weeks after operation, a stout Kirschner wire is inserted through the acromion and into the outer end of the clavicle. By entering the wire at about the posterior angle of the acromion it can be thrust inwards and a little anteriorly to enter the clavicle and to go on into the clavicle for about 2 inches. It is helpful to have facilities for x-ray examination available for this part of the operation, as some difficulty may be experienced in getting the wire to engage firmly in the clavicle. The outer end of the wire can be left projecting through the skin, the site of puncture being sealed off by a collodion dressing. Alternatively, the wire may be cut off close to the acromion so that there is no projection through the skin.



Closure

Skin suture only is necessary. A pressure dressing is applied and the limb is supported in a sling. The latter is sufficient immobilization, since the repair is protected by the metallic internal fixation.

ALTERNATIVE METHOD

When the dislocation is recent it is justifiable to rely on internal fixation alone since natural repair of the torn ligaments can be expected A "sabre-cut incision 8 inches long is used to expose the acromion and the acromio-clavicular joint. The capsule of the joint will be found to be torn. A tunnel is made through the acromion with a $\frac{3}{16}$ inch drill starting in the posterior part of the outer edge of the acromion and aiming inwards towards the outer end of the clavicle. The outer end of the clavicle is exposed through the torn capsule of the acromio-clavicular joint and a tunnel is made along its medullary canal with the $_{16}$ inch drill A Rush" pin $\frac{3}{16}$ inch in diameter and 8–8¼ inches in length is inserted into the tunnel in the acromion and driven on to enter the medullary canal of the clavicle. The pin will usually have to be bent so as to have a curve with an upward convexity The pin will be found to engage firmly as its end approaches the point where the clavicle starts to curve forwards It should be driven home until the hook on its outer end is flush with the acromion. It is helpful to have facilities for x-ray examination available for this part of the operation, as some difficulty may be experienced in getting the pin to run along the medullary canal of the clavicle. The torn capsule is repaired with a few sutures and the skin is closed. A sling is sufficient immobilization.

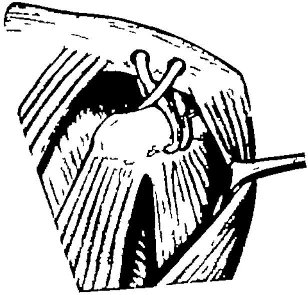
With this relatively strong internal fixation, early movement can be encouraged. The pin should be withdrawn after 4–6 weeks through a separate small incision placed over its outer end. At this stage the repair should be sufficiently strong to permit a gradual resumption of normal activity

POST-OPERATIVE CARE

The sling is retained for 8 weeks, during which time elbow radio-ulnar and hand movements are practised. During this time gentle assisted shoulder movements can be done At the end of the 8 weeks the Kirschner wire is withdrawn and graduated shoulder movements are begun. After 6 weeks the repair should be sufficiently strong to permit a gradual resumption of normal activity

The special complication of this operation is extrusion of the wire due to its not having a sufficiently firm grip in the clavicle This complication may be avoided by using a screw instead of a Kirschner wire, though a screw is rather more difficult to introduce and to remove

[*The illustrations for this Chapter on Stabilization of the Acromio-Clavicular Joint were drawn by Mr R. N Lane*]



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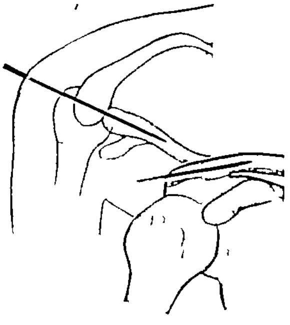

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EXCISION OF THE OUTER END OF THE CLAVICLE

G. L. W. Bonney M.S., F.R.C.S.

Consultant Orthopaedic Surgeon to St. Mary's Hospital and Paddington Green Hospital London Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls Research Assistant to the Institute of Orthopaedics, London

PRE-OPERATIVE

Indications

Persistent pain related to the acromio-clavicular joint following subluxation and unrelieved by conservative measures is an indication for excision. Other indications are osteoarthritis of the acromio-clavicular joint with symptoms unrelieved by conservative treatment, and benign new growths of the outer end of the clavicle.

Special contra-indications

In cases of unreduced complete dislocation of the acromio-clavicular joint with rupture of the coraco-clavicular ligaments, deformity rather than pain is the chief symptom. If in such cases the outer end of the clavicle be excised, deformity from the cut end of the bone frequently persists. Should operation be necessary in such a case it is preferable to repair the coraco-clavicular ligaments in order to restore stability to the scapulo-clavicular articulations.

Pre-operative preparation

No special pre-operative preparation is required apart from that ordinarily undertaken in orthopaedic cases.

Anaesthesia

General anaesthesia is the most satisfactory. Administration by endotracheal tube facilitates towelling and access.

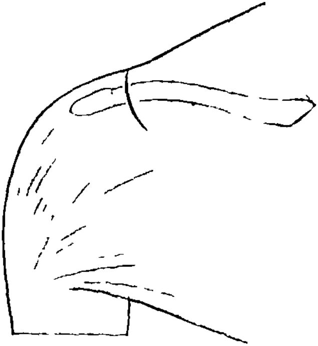
Position of patient

The patient lies on his back with the affected shoulder raised by a small sand-bag placed behind it. The skin of the shoulder area and of the axilla is prepared. Towels are placed to exclude the head and to cover the body and arm. It is not necessary to towel the arm separately. The surgeon stands at the side to be operated on, facing the patient.

THE OPERATION

The incision

1 A short incision is made in relation to the outer end of the clavicle and *following the line of the* skin creases. The skin flaps are dissected back to expose the outer end of the bone and the acromio-clavicular articulation.



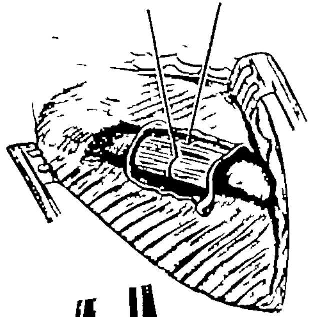
Division of soft tissues and exposure of bone

2 After the outer fibres of the deltoid muscle have been cleared from the anterior surface of the bone the periosteum is divided at right angles to the line of the clavicle. The periosteum on the inner side is pushed back with a rugine.

3

Division of clavicle

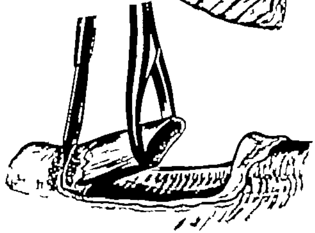
The clavicle is divided about $\frac{3}{4}$ inch from its outer end. The inner limit of the resection of bone is marked by the outer edge of the coraco-clavicular ligament.



4

Removal of outer end of clavicle

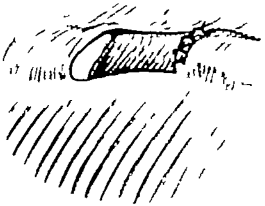
The outer end of the clavicle is now grasped with bone-holding forceps and its remaining soft tissue attachments (capsule of acromio-clavicular joint and attachment of trapezius superiorly) are divided. If there is a meniscus in the acromio-clavicular joint this is removed, but the cartilage on the clavicular surface of the acromion is left undisturbed.



5

Closure

The cut end of the clavicle is covered with the prepared flap of periosteum, but no other deep suturing is required. The skin is closed and a pressure dressing is applied. A sling is sufficient post-operative immobilization.



POST-OPERATIVE TREATMENT

Active exercises for the shoulder can be started two or three days after the operation, and a full range of movement should be regained after three or four weeks.

Reference

Mumford, E. B (1941) *J Bone Jt Surg* **23**, 799

EXCISION OF THE ACROMION

G. L. W. BONNEY, M.S., F.R.C.S.

Consultant Orthopaedic Surgeon to St. Mary's Hospital and Paddington Green Hospital, London; Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls; Research Assistant to the Institute of Orthopaedics, London

PRE-OPERATIVE

Indications

One of the indications for excision of the acromion is the supraspinatus syndrome. In this condition persistent and severe disability may exist after 3–4 months' conservative treatment.

Benign new growths of the acromion process are also indicative of excision.

Special contra-indications

In cases of complete rupture of the supraspinatus tendon, excision of the acromion removes the only fulcrum on which the deltoid muscle can work to effect abduction. In such cases, excision of the acromion may further impair the ability to abduct.

Limitation of passive movement of the shoulder joint contra-indicates acromionectomy. Before operation is undertaken in such cases, a full passive range should be secured by exercises and if necessary by gentle manipulation.

Pre-operative preparation

In cases where there is limitation of passive movement of the shoulder, treatment to restore the passive range will be necessary. Otherwise no special pre-operative preparation is needed.

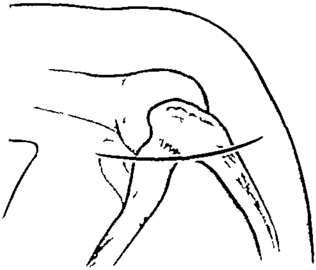
Anaesthesia

General anaesthesia is the most satisfactory. Administration by endotracheal tube facilitates the towelling of the area and enables the surgeon to work from the head end of the table.

Position of the patient

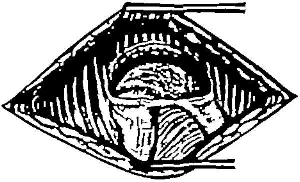
The patient is placed to lie on the unaffected side. The skin of the shoulder area, the related part of the neck, the axilla and upper arm are prepared. Towels are placed over the head and over the body and in front of and behind the shoulder. The arm, forearm and hand are wrapped in another towel, which is conveniently secured by a sterile bandage or by stockinet.

THE OPERATION



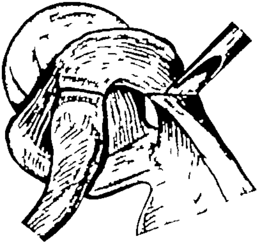
The incision

1 The incision is of the "sabre-cut" type, following the line of the acromio-clavicular joint and being prolonged anteriorly over the deltoid and posteriorly over the base of the acromion.



Skin flaps

2 The outer skin flap is turned up so as to expose the upper surface of the acromion and the attachment of the deltoid muscle.



Division of periosteum and ligaments

3 The periosteum is incised along the base of the acromion in line with the acromio-clavicular joint, and raised towards the midline with a rugine. The superior part of the capsule of the acromio-clavicular joint is divided.

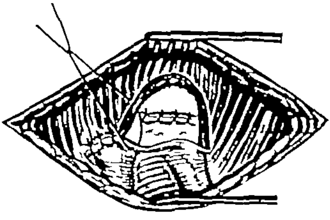
Removal of the acromion

4 The base of the acromion is now divided with an osteotome, the line of section passing from before backwards along a line just medial to that of the acromio-clavicular joint. The detached acromion is now grasped with bone-holding forceps and lifted up while the remaining soft-tissue attachments—deltoid muscle peripherally, remains of acromio-clavicular joint capsule and coraco-acromial ligament inferiorly and trapezius attachment medially—are divided close to the bone.

Inspection of sub-acromial bursa and closure

5 The removal of the acromion affords a good view of the sub-acromial bursa and of the rotator cuff. The bursa is often opened during the removal of the bone but if not, it is necessary to open it in order to see the underlying structures. The assistant moves the arm so that the bursa and the tendinous cuff can be freely inspected.

If possible, the bursa is closed with fine, plain catgut. The deltoid muscle is sutured back with silk to the cut edge of the bone and the skin also sutured. A sling is sufficient immobilization.



POST-OPERATIVE TREATMENT

Active exercises for the shoulder can be started a few days after operation. At first, abduction should be performed in the horizontal plane, with the limb supported in slings so that the effect of gravity is eliminated. Full movements are usually regained some 4–6 weeks after operation.

[The illustrations for this Chapter on Excision of the Acromion were drawn by Mr R. N Lane]

Reference

Armstrong, J R. (1947). *Lancet*, **1**, 91

OPERATIONS ON SUPRASPINATUS TENDON

G L W BONNEY M S F R.C.S

Consultant Orthopaedic Surgeon to St. Mary's Hospital and Paddington Green Hospital, London Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls Research Assistant to the Institute of Orthopaedics London

PRE-OPERATIVE

REPAIR OF TENDON

Indications

In the acute phase after injury to the shoulder it is often impossible to make a definite diagnosis of rupture of the supraspinatus tendon. For this reason it is recommended that when a patient presents in the acute phase with signs suggestive of damage to the musculo-tendinous cuff the diagnostic test of filling the subacromial bursa with procaine should be used. If, when this has been done, the patient immediately regains full active movement of his shoulder it is unlikely that operative treatment will be required. If the relief of pain by the local analgesic is not accompanied by restoration of active movement, then it is likely that a major tear is present. Under those circumstances it is right to proceed with arthrography of the shoulder If this confirms the presence of a major tear of the musculo-tendinous cuff, operative repair is advised.

Special contra-indications

In many cases, when the patient is seen long after the original injury the degree of disability will not be sufficient to justify operative repair nor indeed, is it likely that operation will produce a full restoration of function.

Limitation of passive motion of the shoulder is likely to mar the operative result, and if possible should be overcome by intensive physiotherapy before operation is undertaken.

Special pre-operative steps

Introduction of procaine into the subacromial bursa

After preparation of the skin, the needle is introduced at a point on the anterior aspect of the shoulder about ½ inch in front of the acromioclavicular joint. It is passed almost directly posteriorly to enter the bursa. In cases where a major tear is present blood-stained fluid may be aspirated. Adequate analgesia can be obtained by the introduction of 10 ml. of 1 per cent procaine.

Arthrography of the shoulder

After preparation of the skin, a short-bevelled needle is introduced at a point on the anterior aspect of the shoulder 1 inch in front of the acromioclavicular joint. It is passed almost directly downwards so that its point enters the articular cartilage of the head of the humerus. The needle is then withdrawn a very short distance and the injection is made with 85 per cent diodone 7 ml. is the amount usually needed to fill the joint. The needle is withdrawn and radiographs in various positions of the shoulder are taken.

When the musculo-tendinous cuff has been torn, the opaque fluid will be seen freely to enter the subacromial bursa, but when no tear is present little or no fluid will enter the bursa. Some care is necessary in the interpretation of these arthrograms and they are only of full value when used in conjunction with physical signs and with the procaine test.

Application of body part of shoulder spica

If post-operative immobilization by plaster is to be used, it is a good plan to put on the body part of the shoulder spica before operation, as this step is much easier in the conscious than in the unconscious patient.

Anaesthesia

General anaesthesia is essential. Its administration by endotracheal tube facilitates towelling and access to the shoulder

Position of patient

The patient lies on his back, with the affected shoulder thrown forwards by a sandbag placed behind the vertebral border of the scapula. Another sandbag is placed behind the buttock on the affected side, and the table is tilted so that the head end is raised. The skin of the shoulder area and of the upper limb is prepared, and towels are placed so as to exclude the head and trunk and in order to leave the arm free to be manipulated by the assistant.

The surgeon stands on the affected side and is able to look down on the superior aspect of the shoulder

OPERATION FOR CALCIFIED DEPOSIT

Indications

This operation is indicated for acute or chronic supraspinatus tendinitis associated with the presence of a calcified deposit in the tendon, with symptoms not resolving rapidly with conservative treatment.

Anaesthesia

General anaesthesia is most satisfactory but if for any reason it is contra-indicated local analgesia can be used.

Position of patient

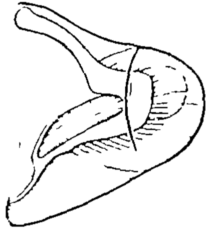
The patient lies on his back the shoulder of the affected side being thrown forwards by a sandbag placed along the vertebral border of the scapula. The operator stands facing the patient, on the affected side.

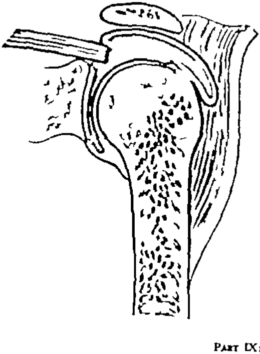
THE OPERATIONS

REPAIR OF TENDON

Incision

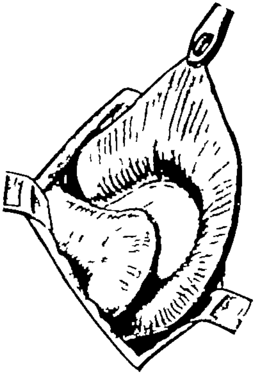
1 The incision is of the sabre-cut type, 6 inches long running antero-posteriorly in the para sagittal plane of the acromioclavicular joint.





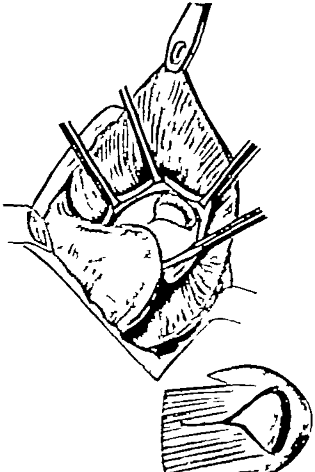
Skin flaps

2 Both flaps are raised to expose the superior aspect of the clavicle and acromion, and the origin of the deltoid muscle.



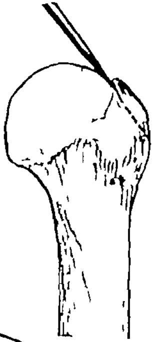
Detachment of deltoid muscle

3 The deltoid muscle is detached from its origin from the clavicle and acromion. The anterior detachment goes right up to the anterior border of the muscle, so that a flap of muscle can be swung outwards to expose the underlying structures. The posterior detachment need not be so extensive unless a complete rupture of the whole musculo-tendinous cuff has to be dealt with. The elevation of the deltoid will expose the roof of the subacromial bursa.



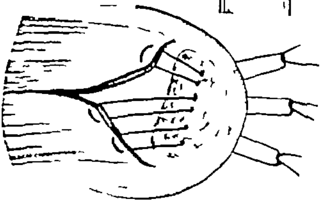
Exposure of lesion

4 The roof of the bursa is opened. This will enable the tear to be seen. The tear involving *the synovia of the floor of the bursa as well* as the tendon, is usually triangular in shape, since the supraspinatus tendon retracts backwards as well as medially and since a vertical component of the tear may be present in addition to a transverse one. In cases of complete rupture of the whole musculo-tendinous cuff the tear may be crescentic in shape



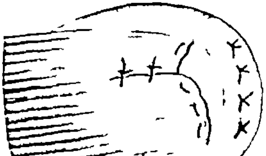
Reduction of greater tuberosity

5 Because the bulk of the repaired tendon together with that of the greater tuberosity may form a block to abduction, it is a good plan to trim down the tuberosity When this has been done, the cut surface of the bone will form a good point of application for the end of the tendon



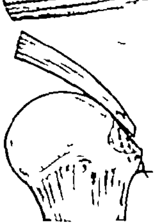
Insertion of sutures

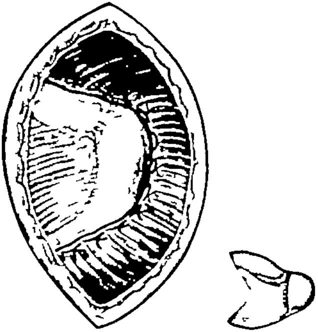
6 After the edges of the defect in the tendon have narrowly been trimmed, the sutures are inserted. These should be of stainless steel or of strong silk, and the number to be used will vary with the extent of the tear They are of the mattress type, catching the tendon at one end and passing through the bone in the site of the greater tuberosity at the other



Tying of sutures

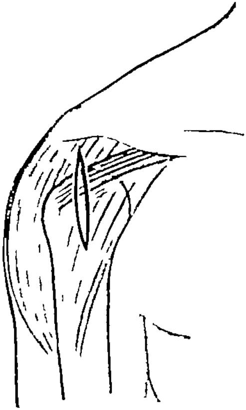
7 The assistant abducts and laterally rotates the shoulder and the sutures are tightened and tied. In favourable circumstances the tendon will be brought down to the cut surface of the bone where the greater tuberosity has been excised At this stage any vertical component of the tear can be repaired.





8 **Closure**

The deltoid muscle is reattached to the clavicle and the acromion with mattress sutures, some of which are passed through the bone. The skin is then closed.



OPERATION FOR CALCIFIED DEPOSIT

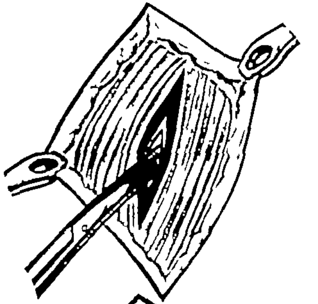
9 **Incision**

A short vertical incision is made on the anterior aspect of the shoulder

Exposure

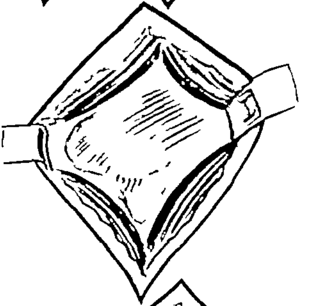
The underlying bursa

10 The deltoid muscle is split along the line of its fibres to expose the underlying bursa covering the tendon of the supraspinatus.



The tendon and synovia

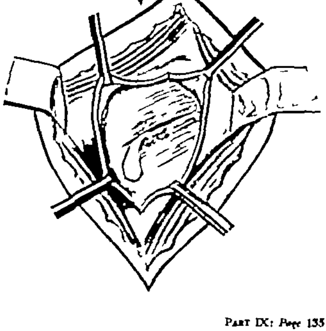
11 Opening the bursa exposes the tendon which is covered by the synovia of the floor of the bursa. The calcified deposit is visible through the synovia.



Removal of calcified deposit

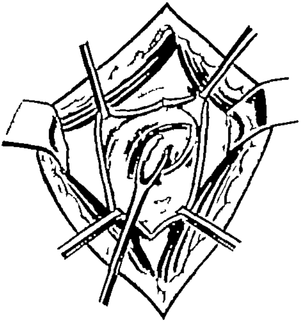
Incision at deposit site

12 The tendon is incised in the line of its fibres at the site of the deposit. In acute cases the deposit will extrude spontaneously



Curettage at deposit site

13 The deposit is fully removed with the curette. In some cases, when a very large deposit has been removed, the defect left is so big that it is necessary to close it with one or two sutures. In most cases, however no repair is needed.



Closure

The edges of the split in the deltoid muscle usually fall together without needing any sutures, and finally the skin is closed.

POST-OPERATIVE CARE AND COMPLICATIONS

REPAIR OF TENDON

If plaster is used, the shoulder spica is completed by the addition of the arm component. Alternatively an abduction frame may be used. The position of immobilization is one of abduction, flexion and some external rotation. Immobilization in abduction is continued for 6 weeks, at the end of which time graduated movements are begun. It is a good plan to dispense with immobilization gradually rather than all at once. Rehabilitation is usually a slow process after this operation, and it is generally 6 months before a good range of active movement is restored.

Special complications

In cases operated on some time after injury it may be extremely difficult to get good approximation of the tendon to the bone The substance of the tendon is often degenerate and does not hold sutures at all well. In these circumstances repair may be effected by the approximation of the two tendinous limbs of the defect. This often enables the remaining defect to be closed by suture of the remainder of the tendinous edges to bone.

OPERATION FOR CALCIFIED DEPOSIT

Active movements are encouraged from the start, and it is usually only a matter of a week or two before a painless full range is obtained.

[*The illustrations for this Chapter on Operations on Supraspinatus Tendon were drawn by Mr R. N Lane*]

OPERATIONS FOR RECURRENT DISLOCATION OF THE SHOULDER

THE PUTTI-PLATT OPERATION

H. OSMOND-CLARKE, C.B.E., M.B., B.CH., F.R.C.S. (I.), F.R.C.S. (ENG.)

Orthopaedic Surgeon, the London Hospital; Consultant Orthopaedic Surgeon, Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry; Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

PRE-OPERATIVE

Indications

Operative stabilization is advisable if repeated dislocations occur with minimal violence and with sufficient frequency to cause troublesome disability. The aim of the Putti-Platt operation is two-fold: to produce a strong fibrous barrier to the exit of the head of the humerus in front, and to produce some permanent restriction in the extremes of the movements which allow dislocation—namely, extension and lateral rotation. To perform the operation properly it is essential to have a good exposure and to proceed step-by-step as outlined below: if short cuts are attempted the result is usually imperfect and may be disastrous through injury to vessels or nerves.

Position of patient and anaesthesia

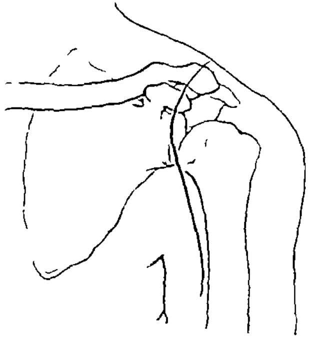
The patient lies on his back with a small sandbag between the shoulders and the head of the table elevated so that a slight sitting effect is given. Two towels are placed under the head and the top one is folded over to cover the head and face from the chin upwards. The arm should be draped in sterile towels so that it can be manoeuvred by an assistant as required.

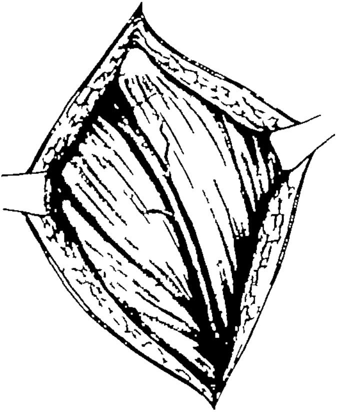
General anaesthesia with an endotracheal tube is satisfactory.

THE OPERATION

The incision

1 After infiltration of the skin and subcutaneous tissues with Xylocaine-hyalase-adrenaline solution (for subcutaneous and intramuscular injection a total of 120 ml. of 0.5 per cent Xylocaine, ½ ampoule of hyalase and 12 min. of 1:1,000 adrenaline is suitable) a skin incision is made starting above the outer quarter of the clavicle and curving downwards across the coracoid process, following the anterior border of the deltoid and finishing about 3 inches distal to the anterior fold of the axilla. The skin and fat are divided and retracted, exposing the delto-pectoral layer—the first muscle layer

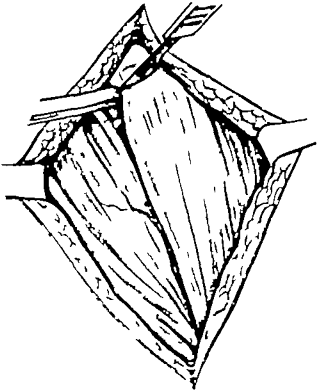




2

Identification of cephalic vein

The groove between the deltoid and the pectoralis major is usually easily shown by the cephalic vein, or if the latter is overlapped by the muscles, by a "yellow line" of fat. Time is well spent on patiently identifying and ligating the upper ramifications of the cephalic vein, including the main stem, and numerous small arteries.



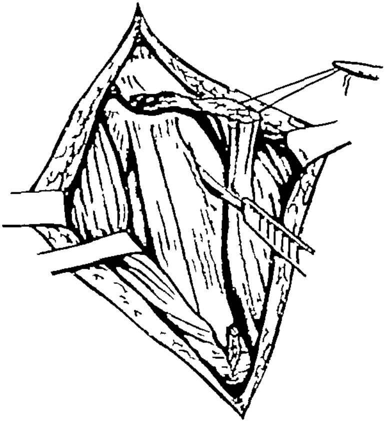
3

Division of deltoid muscle

By blunt dissection the two muscles are separated until the second muscle layer—the coraco-brachialis layer—is exposed. Exposure is more satisfactory with less trauma to the deltoid muscle by retraction, if the clavicular head of the deltoid is detached. This may be done subperiosteally but the writer's preference is to divide the muscle, after infiltration with the adrenaline Xylocaine solution about half an inch distal to its origin, because it is then easier to reattach it later

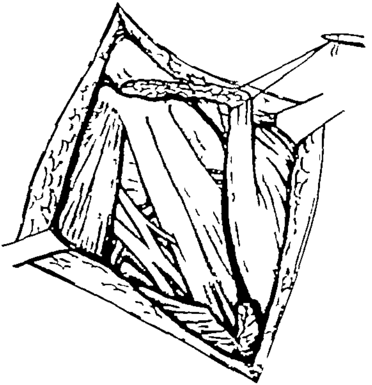
Full exposure of coraco-brachialis muscle layer

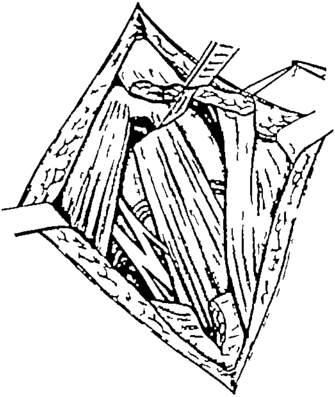
4 The detached portion of the deltoid is retracted by traction on a suture. The proximal inch or so of the insertion of the pectoralis major is divided. The coraco-brachialis layer—made up of the conjoined tendon of coraco-brachialis and the short head of biceps—is now fully exposed with the tendon of the biceps muscle lying along its outer border and the pectoralis minor almost blending with it medially. The conjoined tendon is freed but it is important to remember that close to its medial border lie large vessels and nerves and that the musculo-cutaneous nerve enters the medial border at varying levels, though never more proximal than some 2 inches below the coracoid process. Hence dissection should not be extensive or clumsy along the medial border of the muscle.



Recognition of major nerves and vessels

5 The axillary artery, the outer cord of the plexus, and the lateral and medial heads joining to form the median nerve, and the ulnar nerve are in close proximity. (These are shown clearly in the drawings for purposes of warning: it is not necessary to dissect them out so elaborately at operation.) The anterior humeral circumflex artery and venae comites—important landmarks—can be seen proceeding transversely beneath the muscle. Deeper still a glimpse is caught of the third muscular layer—the subscapularis—also running transversely.

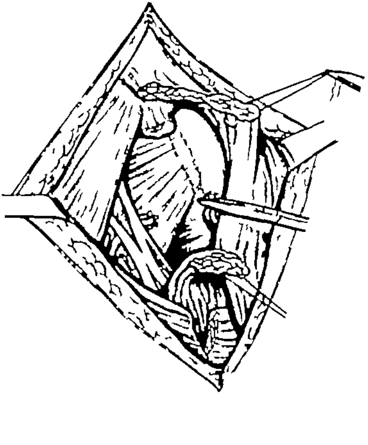




6

Division of coraco-brachialis muscle

A blunt dissector is passed under the coraco-brachialis muscle which is divided about [illegible] inch distal to the coracoid process (the writer prefers this to detaching the tip of the coracoid because of the ease of subsequent reattachment)



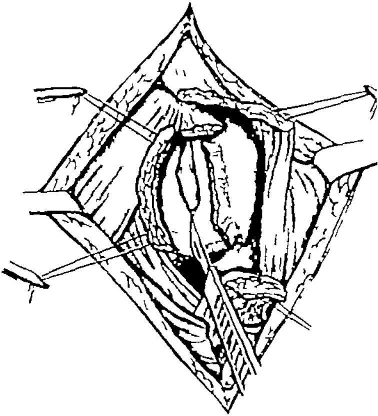
7

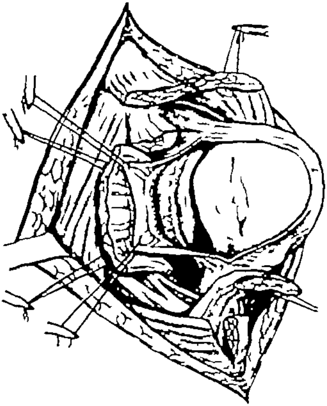
Site of division of subscapularis muscle

The coraco-brachialis muscle is retracted downwards by traction on a suture and the anterior humeral circumflex vessels are divided and ligated. These three vessels are constant, easily identified and indicate sufficiently accurately the lower margin of the subscapularis which is now fully exposed at its insertion into the humerus. The upper and lower borders stand out more readily if the humerus is now rotated laterally

Entry into capsule of shoulder joint

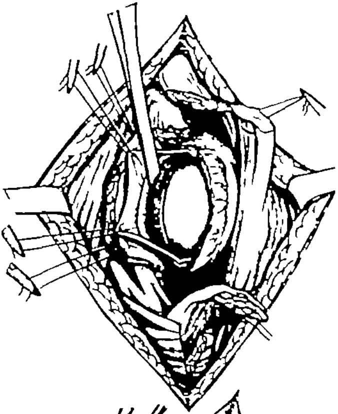
8 The upper border of the subscapularis muscle lying under the stump of the coraco-brachialis is freed by sharp dissection if possible a blunt dissector is passed downwards along the deep surface of the muscle Most of the tendon of the muscle is intimately joined to the capsule of the shoulder joint so the blunt dissector inserted at the upper margin of the muscle enters the shoulder joint and cannot be brought out at the lower margin of the muscle. This is not a matter of any importance because both subscapularis and capsule are divided at the same level—about an inch from the humerus (in this drawing the muscle and capsule are being divided separately which is sometimes possible) Sutures in the proximal (muscular) part of the subscapularis are used to prevent spontaneous retraction of the muscle and act as retractors.





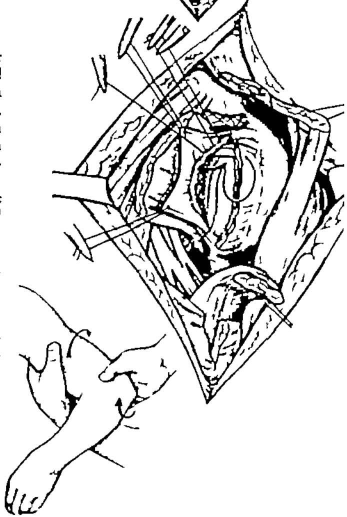
Demonstration of humeral defect

9 The capsule is retracted to show the separation of the glenoid labrum from the margin of the glenoid rim and the capsule is stripped from the neck of the scapula. If the humerus is fully rotated laterally and subluxated the defect on the back of the head will be revealed. (This is an unnecessary manoeuvre except for the academic interest of demonstrating the defect it entails some risk of over-stretching the brachial plexus.)



Preparation of neck of scapula

10 The neck of the scapula—if the capsule is found to be stripped from it—is "rawed" with a fine osteotome. It is to this area that the distal (tendinous) stump of the subscapularis and capsule is to adhere. If the capsule is not found stripped from the bone it suffices to scarify the deep surface of the capsule at its junction with the bone.

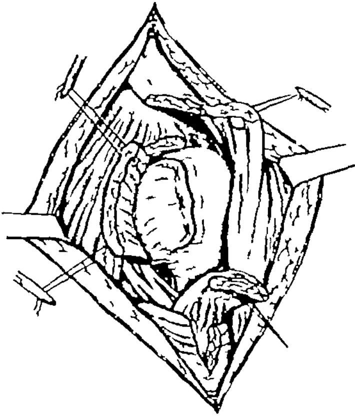


Attachment of muscle stump

11 The attachment of the distal musculo-capsular stump to the anterior margin of the glenoid and anterior surface of the neck of the scapula is the "linchpin" of the Putti-Platt procedure. An important step is for an assistant to push the head of the humerus backwards by a combination of backward pressure on the mid-arm and forward pressure on the elbow (*inset*). Sutures of No. 4 London Hospital chromic catgut on a medium sized bayonet-pointed Mayo's needle should be used. The needle is passed through the remains of the glenoid labrum and the adjoining capsule, then through the distal musculo-capsular stump and back again close to where it started, in the form of a mattress stitch. When tightened this draws the tendinous stump on to the scarified area of the bone. About five or six of these sutures are necessary; all are inserted and then tied one by one from above downwards with the patient's forearm resting on his chest—that is, with the humerus rotated medially. (There are so many sutures with haemostats attached that to avoid confusion the mattress sutures should each be held with two haemostats, as in the illustration.)

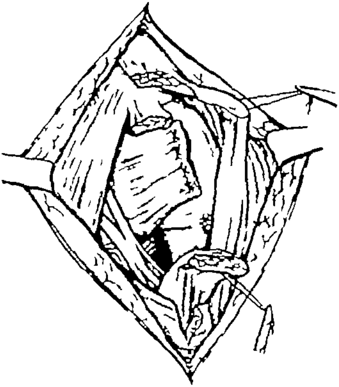
Closure of capsule

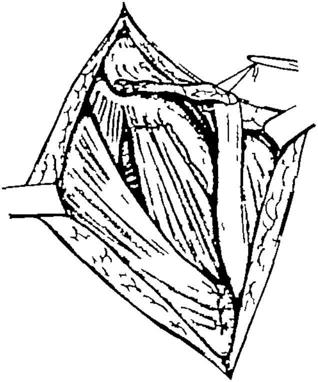
12 The proximal end of the capsule is then overlapped across the musculo-capsular cuff (like a double-breasted coat) and sutured usually to the base of the cuff



Suture of subscapularis muscle

13 The proximal end of the subscapularis muscle is pulled (like an overcoat) across the overlapped capsule and sewn to the scarified tissues in the region of the greater tuberosity and the bicipital groove. The correct amount of tension is that which allows 45 degrees of lateral rotation. A rough guide of conduct is that the more severe the labrocapsular tear and the younger the patient, the tighter should be the overlap.

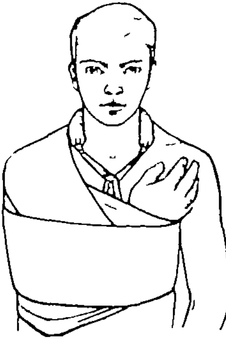




14

Suture of muscles wound closure

The various divided muscles are sutured with medium plain catgut, and the skin wound is closed.



15

Application of sling

A cuff and-collar sling is applied and the arm is bandaged across the chest with the tips of the fingers almost reaching the opposite shoulder so that the elbow is kept well forward bandaging should be reinforced with several layers of Elastoplast.

ALTERNATIVE PROCEDURES

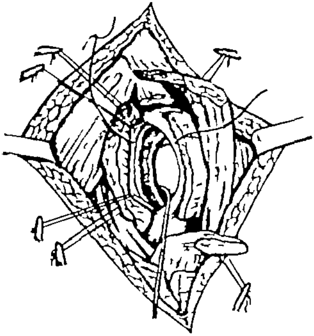
THE BANKART OPERATION

16 The object of the Bankart operation is to re-attach the capsule and the glenoid labrum to the front of the glenoid margin.

The exposure is the same as for the Putti Platt operation. When the joint has been opened the capsule and the glenoid labrum will usually be found stripped away from the bone over a distance of about an inch. With a suitable instrument (a right-angled dental drill is the best) a series of small holes are drilled through the anterior rim of the glenoid. These holes provide suitable purchase for sutures by which the capsule and glenoid labrum are secured firmly to the bone margin. The closure is carried out anatomically layer by layer without overlapping the subscapularis as in the Putti-Platt operation.

After the operation the arm is kept bandaged to the side for 8 weeks, and thereafter active exercises are encouraged.

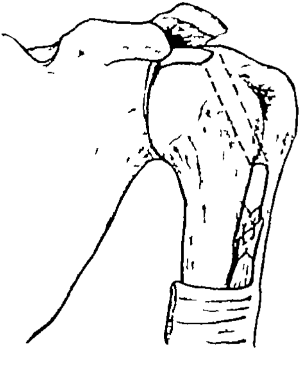
The results of the Bankart operation, properly carried out, are good, but they are not superior to those of the Putti-Platt operation. Since the latter is easier to perform than the Bankart operation it is preferred by the author



THE NICOLA OPERATION

17 The principle of this operation was to construct a new intra-articular ligament from the tendon of the long head of the biceps. The tendon was divided at the lower end of the bicipital groove of the humerus, re-routed through a hole drilled centrally through the humeral head, and sutured to the soft tissues near its point of emergence from the bone at the bicipital groove.

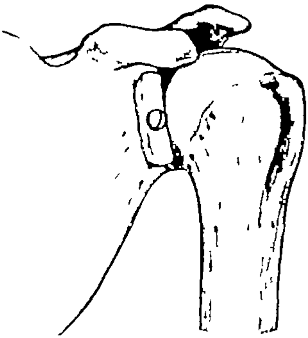
The recurrence rate after the Nicola operation is so high (over 88 per cent in one series) that the operation has practically been abandoned.



BONE BLOCK OPERATIONS

18 Some surgeons—especially on the Continent—have favoured operations that set out to create a bony buttress at the front of the glenoid margin. In effect, this deepens the glenoid socket and thus prevents forward displacement of the humeral head. One of two methods may be used, or both may be combined. In one method the coracoid process is fractured at its base and turned downwards to lie in close relationship to the front of the humeral head. In the other method a block of bone—usually obtained from the ilium—is fixed with a screw to the front of the neck of the scapula in such a way that it projects forward from the glenoid margin, thereby deepening the socket.

Bone block operations are difficult to carry out with the necessary precision, and in general they are no more effective than the relatively simple Putti-Platt operation. For this reason they have not been received with much favour in Great Britain.



POST-OPERATIVE CARE AND COMPLICATIONS

The position established at operation is maintained for 5 weeks thereafter mobilization and rehabilitation are commenced. Sutures are removed on the tenth day In women one exposure of superficial x-rays (800–400 r) may be given when the wound is healed to minimize the risks of keloid formation. Too early mobilization of the shoulder should be avoided, both to prevent over-stretching of the capsulorrhaphy and to guard against broadening and thickening of the scar which in a woman can be an unsightly cosmetic defect.

[*The illustrations for this Chapter on Operations for Recurrent Dislocation of the Shoulder were drawn by Miss Christine M Lamb*]

ARTHRODESIS OF THE SHOULDER

H Osmond-Clarke, C B E., M.B., B Ch., F R.C.S. (I.), F.R.C.S. (Eng.)

Orthopaedic Surgeon, the London Hospital Consultant Orthopaedic Surgeon Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

PRE-OPERATIVE

Indications

Arthrodesis of the shoulder is undertaken mainly for inflammatory conditions such as tuberculosis, much more rarely than formerly for paralytic lesions, and occasionally for rarities like osteoarthritis of the shoulder gross injuries, and after the resection of benign neoplasms.

The shoulder may be approached either from the front (or antero-superiorly) or from behind.

Position of patient

Anterior approach

The patient lies on the back with a small sand-bag under the scapula and buttock so that he is slightly tilted towards the opposite side.

Posterior approach

The patient lies prone with the face turned towards the opposite side and the affected arm hanging over the edge of the table. The body part of a plaster of Paris shoulder spica should have been applied some days previously

Contra-indications

Distraction at the shoulder joint —The posterior operation should not be done for paralytic lesions of the shoulder unless it is combined with intra-articular ablation of the joint and fixation of the humeral head to the glenoid by pin or screw otherwise the graft may act as a fulcrum about which the head of the humerus is levered out of the glenoid.

Anaesthesia

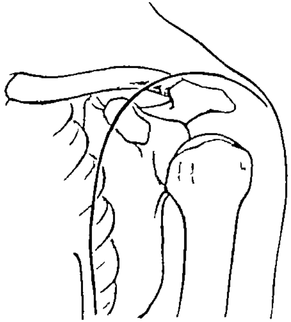
General anaesthesia with an endotracheal tube is satisfactory

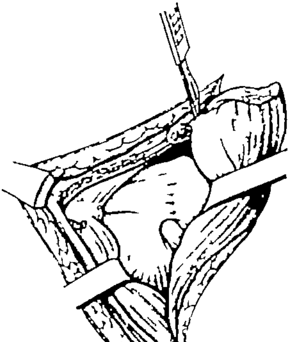
THE OPERATIONS

THE ANTERIOR OPERATION

The incision

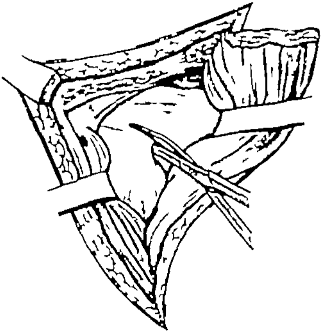
1 The incision is like that used for recurrent dislocation of the shoulder (*see* page 188) except that it is extended backwards to a point just behind the posterior margin of the acromion.





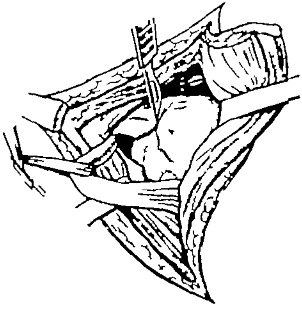
Exposure

2 The delto-pectoral groove is identified and the same procedure carried out as in the similar stage of the Putti-Platt capsulorrhaphy (*see* page 188) The cephalic vein is tied, and the deltoid muscle is detached from its clavicular attachment and from the anterior two-thirds of its acromial attachment. This exposes the coracoid process, the musculo-tendinous cuff and capsule, and the long tendon of the biceps.



Division of capsule

3 The transverse humeral ligament and the capsule above it are divided longitudinally to free the tendon of the biceps.



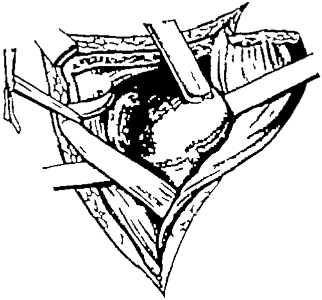
Entry into joint

4 The tendon of the biceps is retracted forwards and the musculo-tendinous cuff and capsule are divided transversely opening up the shoulder joint.

5

Preparation of bony surfaces

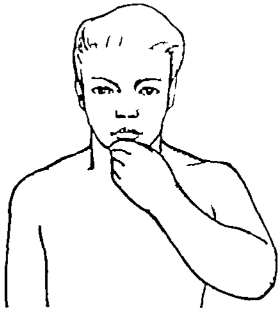
With a gouge the joint surfaces are thoroughly rawed, all the remains of the cartilage and sclerotic bone being removed to expose bleeding cancellous bone.



6

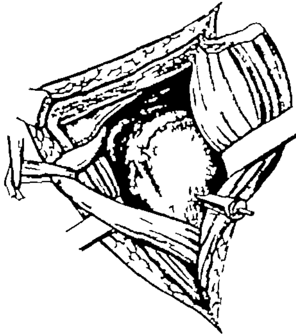
Positioning of arm

The humeral head is placed in contact with the glenoid and the arm is held in the position that will ensure optimum function. This is in fact the position which allows the patient to get his hand to his mouth and allows the arm to come to the side in repose. In an adult it amounts to 40 degrees of abduction, 15–25 degrees of forward flexion, and 25–30 degrees of medial rotation. An adolescent can be allowed some 60 degrees of abduction because of the greater mobility of the scapula.



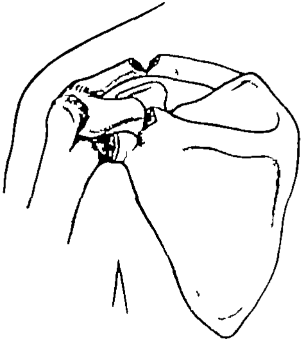
Insertion of guide wire

7 While the above position is carefully maintained by an assistant a guide wire is inserted from the outer aspect of the humerus at an angle of about 60 degrees so that it penetrates the humeral head and the glenoid it should be directed upwards and backwards. Its position is checked by radiographs.



Insertion of Smith-Petersen nail

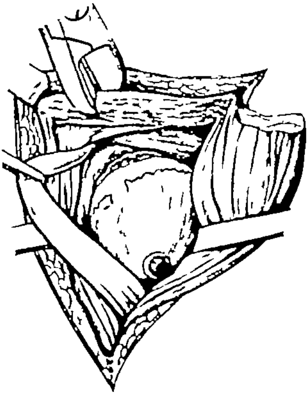
8 When a satisfactory position of the guide wire has been achieved a cannulated Smith-Petersen nail is driven over the wire and firmly impacted. The wire is removed.



Reinforcement of arthrodesis

Technique

9 The arthrodesis is reinforced by bending the rawed acromion downwards and inserting it into a notch cut in the humerus.



Mobilisation of acromion

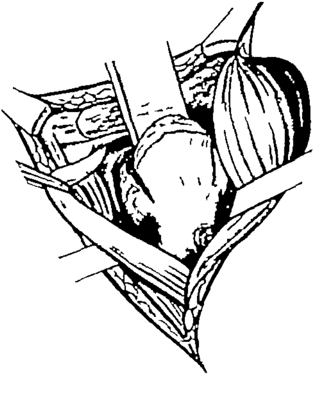
The above manoeuvre is facilitated by partly dividing the clavicle and the spine of the scapula. The soft-tissue attachments should be left intact to ensure an adequate blood supply and to preserve a reasonably stable "hinge"

10 *Part-division of clavicle*.—The clavicle is partially divided by means of bone-cutting forceps.

11 *Part-division of scapula.*—The spine of the scapula is cut with bone-cutting forceps.

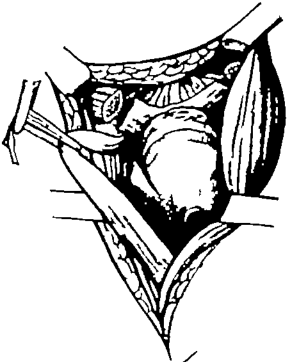
12 *Formation of notch in humerus*

The notch in the humerus is made by inserting a chisel from above downwards and fracturing the greater tuberosity outwards.



Completion

13 The outer parts of the clavicle and acromion are bent down into the gap formed by the outwardly levered tuberosity One or two *sutures keep them in snug contact. The wound* is closed in layers.



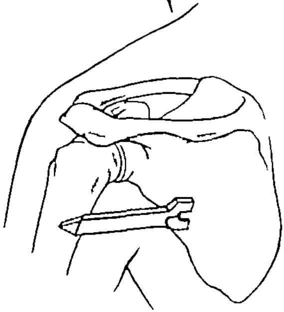
Alternative techniques

Other techniques are in use. Some surgeons prefer to use a lag-screw rather than a Smith-Petersen tri-flanged nail. Others, notably Charnley and DePalma, use compression on Steinmann's pins passed through the clavicle and acromion above and the neck of the humerus below

THE POSTERIOR OPERATION

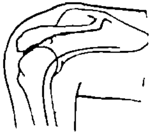
Technique

14 The aim of the operation is to insert a tibial graft, cut as illustrated, between the scapula and the humerus about 2 inches below the shoulder joint. It has been claimed by Brittain, the originator of this operation that the compression force exerted by the arm's constantly tending to adduct ensures more certain union than other methods.



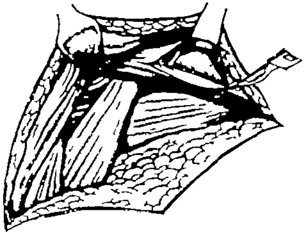
The Incision

15 A curved incision is made, beginning near the lowest third of the scapula and extending along the axillary border and down the arm for about 4 inches.



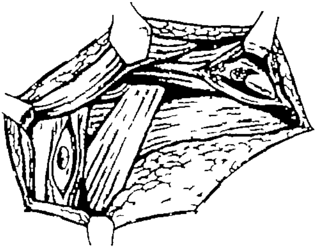
Exposure

16 The incision is carried down through the teres minor muscle on to the axillary border of the scapula. If the circumflex scapular artery is in the way it is divided and ligated. The infraspinatus behind and the subscapularis in front are stripped from the scapula sufficiently to allow a notch to be made in the bone with nibbling forceps.



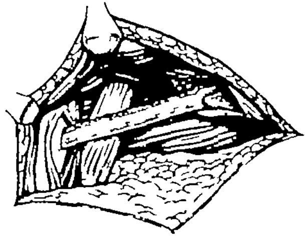
Notching of scapula and drilling of humerus

17 When the axillary border has been notched, the posterior border of the deltoid is retracted and the lateral and medial heads of the triceps are split to expose the shaft of the humerus just below its surgical neck. A suitable hole is bored in the humerus its position and direction are determined with due regard to the length of the graft (cut from the subcutaneous surface of the tibia at the beginning of the operation) and the correct positioning of the arm.



Insertion of graft

18 The graft is embedded firmly in both bones. It is usually easier to place it in the humerus first, and then by manoeuvring the arm to coax the other end into the slot in the scapula. The wound is closed in layers.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

THE ANTERIOR OPERATION

A plaster of Paris shoulder spica is applied: this is not easy on the anaesthetized patient, and it is therefore wise to remove the plaster and the sutures after about 2 weeks and to apply a fresh, snugly-fitting spica which should be retained until union has occurred, usually in about 3–4 months. When the arthrodesis is firm the patient begins a course of exercises to mobilize the scapula on the chest wall and to restore the greatest possible function to the arm.

THE POSTERIOR OPERATION

The patient is carefully turned, and plaster of Paris is applied to the arm and connected with the previously applied body plaster to form a shoulder spica. Stitches are removed in about 2 weeks and a snugly-fitting spica is applied: special care must be taken at this stage to avoid disturbing the attachments of the graft. The plaster must be worn for not less than 4 months because this graft takes a considerable time to revascularize.

[*The illustrations for this Chapter on Arthrodesis of the Shoulder were drawn by Miss Christine M. Lamb.*]

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Gill, A. B. (1931). *J. Bone Jt Surg.*, **13**, 287.
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ANTERIOR TRANSPOSITION OF THE ULNAR NERVE

DONAL BROOKS, M.A., M.B., F.R.C.S (I.)

Consultant Orthopaedic Surgeon, Barnet General Hospital Hertfordshire Consultant Orthopaedic Surgeon at Heritage Schools and Hospital Chailey Clinical Research Assistant Institute of Orthopaedics London

PRE-OPERATIVE

Indications

The ulnar nerve should be transposed in all cases of traumatic ulnar neuritis there is no satisfactory conservative treatment for this condition. The common causes of traumatic ulnar neuritis are (1) Osteoarthritis of the elbow joint. (2) Recurrent anterior subluxation of the nerve on flexion of the elbow (3) Cubitus valgus, following fractures in the region of the elbow

Anaesthesia

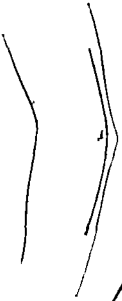
General anaesthesia is best. When local anaesthesia is used the addition of adrenaline (1 200 000) will help to diminish bleeding

Position of patient

The arm should be placed on an arm extension, the shoulder fully rotated laterally the elbow resting on a small sandbag under the lateral epicondyle. The limb should be exsanguinated by means of an Esmarch bandage (Volume 1 Part I, page 89) and a bloodless field maintained by a pressure cuff on the upper arm.

Principles of operation

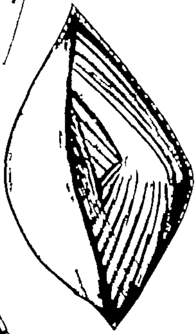
In this operation the ulnar nerve is transposed in front of the medial epicondyle In obese patients the nerve is sometimes placed superficial to the deep fascia. It is wiser however to place it deep to the common flexor origin and under no circumstances should the nerve be buried in the muscle mass, as in this way it is inevitably kinked by the intermuscular septa. Furthermore, the medial intermuscular septum is carefully excised in the lower third of the upper arm If these precautions are not taken then a secondary ulnar neuritis can occur after transposition.



THE OPERATION

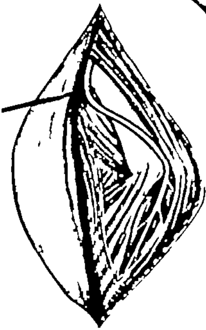
The incision

1 The incision should extend from the lower third of the upper arm to the junction of the upper and middle thirds of the forearm. It lies directly over the course of the ulnar nerve and is usually from 5 to 6 inches long



Reflection of skin and tissue

2 The skin and subcutaneous tissue are reflected in a single flap towards the lateral side. The ulnar nerve can be seen glistening beneath the deep fascia lying directly behind the medial intermuscular septum.

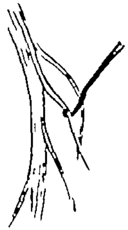


Exposure of nerve

3 The nerve is exposed in the upper arm by dividing the deep fascia lying over it. The incision of the deep fascia is then continued distally in the line of the nerve behind the medial epicondyle and extending into the forearm. The nerve is exposed in the forearm by splitting the muscle fibres of flexor carpi ulnaris. A hook is then placed under the nerve and it is dissected free from its bed. At the level of the elbow joint the motor branches to flexor carpi ulnaris arise

Mobilization of nerve

4 The nerve is mobilized from then onwards by carefully stripping these motor branches proximally. By so doing the nerve can then be transposed.

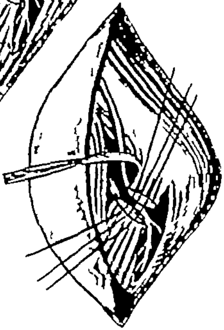


Division of flexor origin

5 The plane of cleavage between brachialis and the flexor origin is then defined and a director is passed beneath the flexor origin. The flexor origin is divided about ½ inch distal to the medial epicondyle until it is quite free. The nerve is then transposed so that it lies next to the median nerve on brachialis.

Excision of medial intermuscular septum

6 The medial intermuscular septum is carefully excised so that the nerve does not become traumatized as it turns forward. The flexor origin is repaired by interrupted sutures and the incision is closed.



POST-OPERATIVE TREATMENT

The limb is immobilized in plaster extending from the axilla to the wrist with the elbow flexed to a right angle. The plaster is maintained for 8 weeks. At the end of this time plaster and stitches are removed and full movement of the elbow is allowed.

[The illustrations for this Chapter on Anterior Transposition of the Ulnar Nerve were drawn by Mr J Wheldon]

OPERATIONS FOR FRACTURE OF THE OLECRANON

M. S. Brett, F.R.C.S.

Senior Registrar, The Royal National Orthopaedic Hospital, London

PRE-OPERATIVE

General indications

The indications for operative treatment of the fractured olecranon depend on a knowledge of the end results of conservative treatment. Fractures without separation should unite without difficulty whether the elbow is immobilized or not.

Fibrous union does not necessarily lead to limitation of movement but always causes loss of power of extension due to lengthening of the triceps (Perkins, 1936). This disability may not be important in the elderly person but it is a serious handicap to a manual worker.

Secondary osteoarthritis in the elbow joint is a complication of any fracture involving the articular surface especially if it causes a persistent irregularity. However, the symptoms may be minimal or absent even in the presence of marked radiographic changes.

Disadvantages of conservative treatment

The rational conservative treatment if the fragments are separated possesses certain theoretical and practical disadvantages.

The elbow must be immobilized in full extension for at least 8 weeks, in which position the hand is relatively useless. Troublesome oedema of the fingers may occur, with the risk of permanent stiffness.

The recovery of function is delayed because of the long period of immobilization.

The final bony union is uncertain and there may be persistent irregularity of the articular surface of the olecranon.

Advantages of operative treatment

In contrast, if operative treatment is to be justified, it must possess corresponding advantages.

Early movement must be allowed to thereby hasten the return of normal function.

Operation must restore the articular surface to normal, and reconstruct the extensor mechanism of the elbow.

Subsequent osteoarthritis must be prevented or minimized.

Two types of operation are available: (1) internal fixation of the olecranon, (2) excision of the proximal fragment and suture of the triceps tendon.

The fixation may be held by means of a screw or by suture of the fragments. Numerous suture materials have been used and it is impossible to recommend any one material. Failure to maintain apposition of the fractured surfaces is attributable to the suture cutting through the bone or breaking. In spite of this complication, however, the functional result is usually good.

Screw fixation depends on an adequate grip on the cancellous bone of the distal fragment. This is ensured by using a Venables lag screw which has a coarse thread ($_{14}$ inch diameter) and should not be less than 8 inches long. If this type of screw is not available a long Sherman screw (inch diameter) should be inserted obliquely so that it penetrates the cortex of the ulna distal to the fracture.

INTERNAL FIXATION OF FRACTURED OLECRANON

Special indications

Fractures of the olecranon process should be treated by internal fixation where (1) there is a transverse fracture with separation of the fragments and (2) there is an associated dislocation of the head of the radius in order to achieve stability

Contra-indications

Fractures with severe comminution are unsuitable for internal fixation A fibrous union may be accepted in elderly people since the only disability is loss of power

Anaesthesia

General anaesthesia is recommended.

Position of patient

With the patient lying supine the arm is brought over the front of the chest so that the back of the elbow lies uppermost. The use of a tourniquet is an advantage, though not essential. A pneumatic cuff is applied as high as possible.

EXCISION OF THE TRICEPS TENDON OF THE OLECRANON

Indications

This is a convenient and sound method of restoring the extensor mechanism to the elbow when the olecranon fragment involves less than 50 per cent of the articular surface or if it is comminuted and therefore unsuitable for internal fixation.

Contra-indications

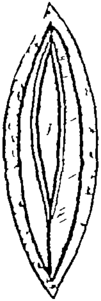
If there is associated dislocation of the head of the radius the joint must be stabilized by apposition of the bony fragments and excision of the proximal fragment is contra-indicated. This operation is also unsuitable where the proximal fragment involves 50 per cent or more of the articular surface.

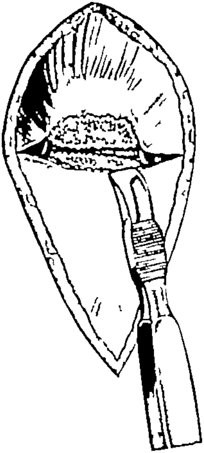
THE OPERATIONS

INTERNAL FIXATION OF FRACTURED OLECRANON

The incision

1 A 3-inch longitudinal incision is made lateral to the tip of the elbow

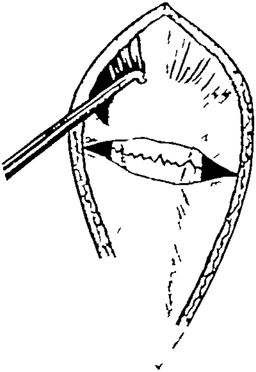




2

Clearing of fracture site

The fracture site is exposed and the blood clot is cleared away from the raw surfaces. The joint surfaces are exposed by retracting the small fragment, which is often more comminuted than the radiograph suggests.



3

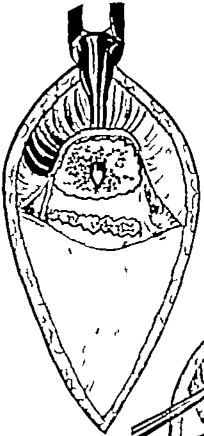
Reduction of fracture

The fracture is reduced accurately and held by means of a bone hook. Hair-line reduction must be obtained. The periosteum must be stripped back a little way to allow inspection of the fracture line on each side of the bone.

Screw fixation

Drilling of olecranon

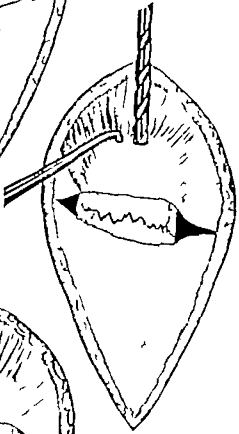
4 A small stab incision is made on to the tip of the olecranon through the tendinous insertion of the triceps. A hole is made with an awl through the proximal fragment so that it emerges from the centre of the fractured surface. The fragment is temporarily released so that this can be inspected.



Drilling of ulnar shaft

5 When accurate reduction has been restored a suitable drill is passed through the same hole and on into the shaft of the ulna, keeping parallel to the subcutaneous border

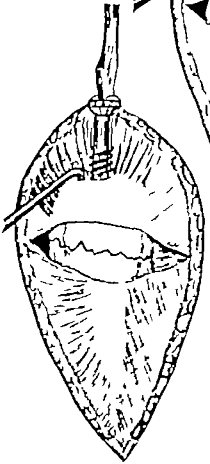
The diameter of the drill should be slightly smaller than that of the screw

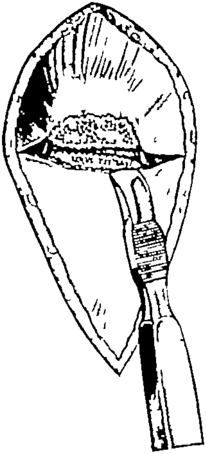


Insertion of screw

6 The screw is then inserted, while the reduction is carefully maintained.

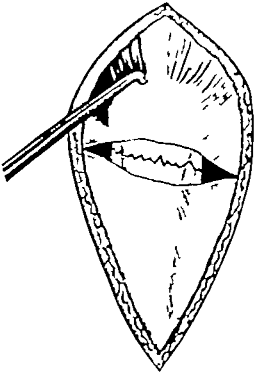
The head of the screw is buried in the triceps tendon. The use of a lag screw allows the fracture surfaces to be firmly apposed.





Clearing of fracture site

2 The fracture site is exposed and the blood clot is cleared away from the raw surfaces. The joint surfaces are exposed by retracting the small fragment, which is often more comminuted than the radiograph suggests.

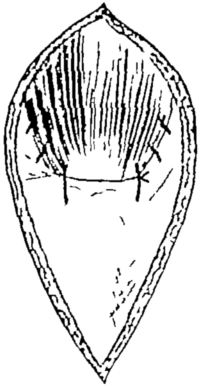


Reduction of fracture

3 The fracture is reduced accurately and held by means of a bone hook. Hair-line reduction must be obtained. The periosteum must be stripped back a little way to allow inspection of the fracture line on each side of the bone.

Repair

9 The triceps expansion and fascia are sutured to complete the repair



POST-OPERATIVE CARE AND COMPLICATIONS

The elbow is immobilized in flexion at 90 degrees for 10 days by means of a plaster slab applied over a firm dressing After the wound is soundly healed active movement is allowed. The same caution in the use of physiotherapy should be observed as after excision of the head of the radius. Finger wrist and shoulder exercises should be given during the post-operative period to prevent stiffness.

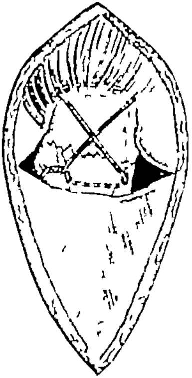
Complications

There are no special complications after this operation. The screw should be removed after the fracture has united if the head of the screw is palpable under the skin.

[*The illustrations for this Chapter on Operations for Fracture of the Olecranon were drawn by Mr F Price*]

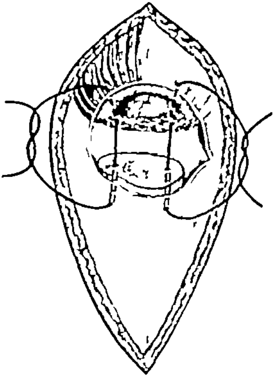
Bibliography

Perkins, G. (1936). *Brit. med. J* 2, 608.
Wainwright, D (1942) *Brit J Surg* 29, 116 403



Suture

7 A hole is drilled transversely through the distal fragment at least inch from the fractured surface. The suture material is passed through this and over the back of the ulna before passing through the triceps tendon at its insertion.
The skin only is closed.



EXCISION AND SUTURE OF THE OLECRANON

The incision and exposure are the same as for internal fixation of the olecranon.

Excision of bone fragment insertion of sutures

8 The bony fragment is excised from the triceps tendon by close dissection, and the tendon is fixed to the raw surface of the ulna by two *strong sutures which are passed through holes* in the bone

Repair

9 The triceps expansion and fascia are sutured to complete the repair

POST-OPERATIVE CARE AND COMPLICATIONS

The elbow is immobilized in flexion at 90 degrees for 10 days by means of a plaster slab applied over a firm dressing After the wound is soundly healed active movement is allowed. The same caution in the use of physiotherapy should be observed as after excision of the head of the radius. Finger wrist and shoulder exercises should be given during the post-operative period to prevent stiffness.

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Bibliography

Perkins, G (1936). *Brit. med. J.*, 2, 608.
Wainwright, D (1942). *Brit J Surg* 29, 118 403

EXCISION OF THE HEAD OF THE RADIUS

M. S. BRETT F.R.C.S

Senior Registrar The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

Fracture

The vast majority of cases of fracture of the head of the radius recover with little or no disability when treated conservatively the improvement in end-results after excision of the head of the radius has been demonstrated only in the more severe types of fracture (Murray 1940)

Excision of the head of the radius is therefore indicated if (1) there is severe comminution with distortion of the articular surface (2) there are any loose fragments, or (3) a marginal segment of the head of the radius has been depressed and more than a third of the articular surface is involved.

In practice it is often difficult to draw a hard and fast line between those cases requiring excision of the head of the radius and those which will gain a good functional result by conservative means. When in doubt it is probably better to err on the conservative side especially if the patient is elderly or does not do heavy manual work.

It is important to remember that the fracture is accompanied by soft-tissue injury varying from a capsular tear to complete dislocation, and the rate of functional recovery is influenced more by the degree of soft-tissue damage than anything else The operation should be performed as soon as convenient after the injury There is no evidence that delaying the operation for a few days affects the post-operative course in any way

Arthritis

When symptoms attributable to degenerative or rheumatoid arthritic changes can be localized to the radio-humeral joint excision of the head of the radius may lead to their relief. But careful judgment is necessary in each case before making the decision to operate.

Contra-indications

Fractures of the head and neck of the radius in children should never be treated by excision of the head of the radius, otherwise unequal growth of the forearm bones with subsequent cubitus varus will follow

Position of the patient

With the patient lying supine the arm is brought over the front of the chest so that the back of the elbow lies uppermost. If a weight is attached to the wrist, the elbow will lie flexed in the required position A pneumatic tourniquet is placed round the upper arm and the limb is exsanguinated by means of an Esmarch bandage (Volume I Part I, page 89)

Anaesthesia

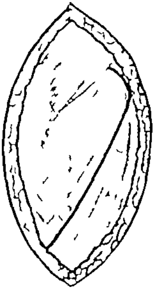
A general anaesthetic is recommended.

THE OPERATION

The incision

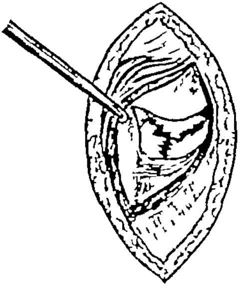
1 A 2-inch longitudinal incision is made over the postero-lateral aspect of the elbow centred over the head of the radius.

Exposure



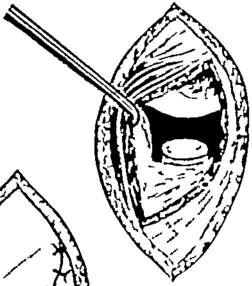
2 The muscle layer is divided between the extensor carpi ulnaris and the anconeus, and the incision is extended upwards by cutting across the fibres of anconeus. In the presence of much bruising and oedema after a fracture, such a clear anatomical approach is impossible and the muscle is incised between the lateral epicondyle and the olecranon. The synovial membrane is incised in the same line.

It is important to remember that the posterior interosseous nerve winds obliquely round the upper end of the radius and will be in danger if the deep dissection is carried to the front of the radius, or extends distal to the annular ligament posteriorly



Clearing of site of fracture

3 The muscle is retracted to expose the head of the radius and the annular ligament. After removal of the blood clot from the joint it is usual to find more fragmentation of the head of the radius than was suspected from the radiograph The capitulum should also be inspected for damage

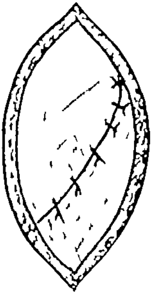


Removal of head of radius

4 Any loose pieces of bone or cartilage are removed and the neck of the radius is divided flush with the top of the annular ligament with an osteotome.

An attempt should be made to reassemble the head of the radius to make sure that no part is still missing in the joint.

When there has been a dislocation of the elbow it is usually necessary to redislocate the joint in order to remove any loose fragments of the radial head that are lying in the anterior compartment of the elbow Sometimes the fragments may be driven through a rent in the capsule and lie outside the joint.



Closure

5 The capsule and muscle are closed with interrupted sutures in one layer Finally the skin is closed with interrupted sutures.

POST-OPERATIVE CARE AND COMPLICATIONS

The elbow should be splinted by means of a plaster slab applied over a pressure dressing in a position of mid-rotation and with 90 degrees of flexion. Exercises for the fingers and shoulder should be started the day after operation and continued through the post-operative period in order to prevent stiffness. The immobilization of the elbow is continued for 3 weeks, after which gentle active movement is allowed. The return of movement at the elbow is usually slow and may be hindered by vigorous exercises or passive movements. Therefore it is probably safer to avoid the use of physiotherapy after this operation except for the preservation of a full range of finger and shoulder movement.

If there is much pain and spasm of the biceps on attempting to straighten the elbow there is no alternative to further immobilization of the joint in plaster for a few weeks, after which the range of movement will often show further improvement.

Joint stiffness —The return of a full range of movement usually takes place after several months and there may be severe permanent loss of movement, especially following dislocation of the elbow

Periarticular ossification —This is the most serious complication and is particularly liable to occur after dislocation of the elbow Often wrongly called myositis ossificans, it is much more likely to be ossification in a subperiosteal haematoma. It is usually situated anterior to the joint in the region of the coronoid process and the liability to its formation is probably increased by early movement of the joint after operation.

[The illustrations for this Chapter on Excision of the Head of the Radius were drawn by Mr F Price]

Reference

Murray R. C. ([illegible]). *Brit J Surg* **28**, 10[illegible]

REMOVAL OF LOOSE BODIES FROM THE ELBOW JOINT

M. S. BRETT F.R.C.S.

Senior Registrar The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

When a loose body causes repeated attacks of pain and locking it should be removed.

Fractures

Fragments of bone including part of the articular surface may break away from the lower end of the humerus as a result of an injury A portion of the capitulum is commonly displaced upwards in front of the lower end of the humerus. If at operation there is no soft-tissue attachment and anatomical reduction cannot be achieved or held, the fragment should be removed. This policy does not apply to the growing child where the bone fragment should always be sutured back in place.

Dislocation of the elbow in children may be complicated by a fracture of the medial epicondyle and this bony fragment, together with the attached flexor muscles, may become trapped in the joint. If the medial epicondyle cannot be replaced by manipulation, operative treatment is required.

Contra-indication

In the absence of symptoms removal of the loose body is not justified.

Pre-operative preparation

This and the post-operative care of the patient are the same as for removal of the head of the radius (*see* page 166) X-ray examination of the elbow should be carried out just before the operation to localize a very mobile loose body

Position of patient

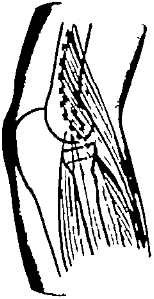
The patient should be supine with the arm on a side table

THE OPERATION

LATERAL APPROACH

The Incision

1 An incision 2 inches long is made along the lateral supracondylar ridge not extending distal to the head of the radius.

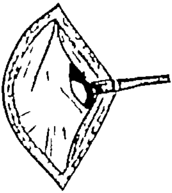


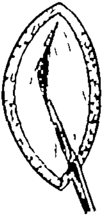
Exposure of Joint

2 The muscle layer is split between the common extensor origin and the extensor carpi radialis longus which is retracted forwards and medially with the radial nerve. The joint is reached by working medially across the anterior surface of the lower end of the humerus.

Incision of Joint capsule

3 The joint capsule is incised and the anterior compartment of the elbow joint is entered. A loose body lying anywhere in the front of the joint can be removed through this incision. The capsule and muscle layers are closed with interrupted sutures.





MEDIAL AND POSTERIOR APPROACHES

4 The posterior approach is identical with the approach for excision of the head of the radius (see page 167)

The medial approach is virtually only necessary for removal of the detached medial epicondyle from the joint. Through a longitudinal incision the flexor muscles and attached medial epicondyle are pulled out of the joint. The bony fragment is re-sutured in its bed. It is probably unwise to transplant the ulnar nerve to the front of the elbow in these circumstances because further muscle damage is inevitable and it can be done at a later date if signs of ulnar neuritis develop

[The illustrations for this Chapter on Removal of Loose Bodies from the Elbow Joint were drawn by Mr F Price]

ARTHROPLASTY OF THE ELBOW

ROBERT ROAF M A F R C S (ENG.) F.R.C.S (ED), M CH (ORTH) B M., B CH., D R.C.O G

Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry
Lecturer in Orthopaedic Surgery at the University of Liverpool

PRE-OPERATIVE

Indications

There are no absolute indications but arthroplasty may be advised for any stiff or painful elbow where the patient is anxious to have movement. It is necessary for the patient to be co-operative and to be able to stand pain he should be at least 12 years of age his general health should be good he should understand that he is unlikely to be able to do very strenuous or heavy work with the arm and that the success of the operation depends largely on his own efforts. In general, the operation is indicated where both elbows are stiff, for example, in selected cases of rheumatoid arthritis or bilateral infective arthritis—for example after smallpox. Occasionally arthroplasty is justifiable following bad intra articular fractures, gunshot wounds or dislocations, but arthrodesis is usually preferable where only one elbow is affected. In order to assess whether or not an arthroplasty of the elbow is likely to be successful it is always wise to start by performing an arthroplasty of the superior radio-ulnar joint by excising the head of the radius In my opinion, this is an essential preliminary before attempting an arthroplasty of the humero-ulnar joint and in the subsequent description I assume that the head of the radius has already been excised and that the patient has demonstrated his suitability for a further arthroplasty by his having regained good rotation movements of the forearm. Some patients are satisfied with the extra function obtained from improved rotation of the forearm and do not wish for a further operation. In all cases this smaller test procedure enables both surgeon and patient to assess whether or not to proceed with a humero-ulnar arthroplasty

Contra-indications

Tuberculosis, extensive fibrosis, recent active infection, and extensive wasting of muscles, are the main local contra-indications. It is not advised in children or in patients who for one reason or another are unlikely to be able to co-operate in the difficult and exacting after-treatment. In all cases, before coming to a final decision, the patient s work, age, general condition and temperament and the condition of his other joints must be considered.

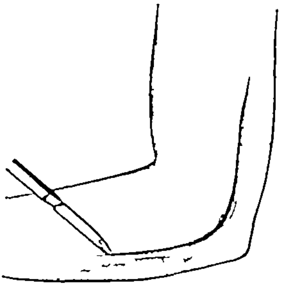
Pre-operative preparation

The arm should be shaved and washed from the finger tips to axilla and the whole arm sprayed or painted with a suitable antiseptic. This should be performed three times during the 48 hours preceding the operation.

Anaesthesia and position of patient

General anaesthesia is essential. It is important to render the field of operation bloodless with a pneumatic tourniquet applied high up the arm and held in place by a bandage which may also be anchored round the patient s neck. Before inflating the tourniquet the limb is exsanguinated with an Esmarch bandage.

The patient lies supine with the affected arm lying horizontally at right angles to the body on a supporting arm board or table. It is important that the shoulder should be sufficiently mobile to allow the humerus to be abducted and externally rotated so that the arm can lie in this position with the palm looking up If the shoulder is stiff it adds greatly to the difficulties of the operation and a determined effort should be made to mobilize the shoulder before operation. The surgeon sits in the angle between the arm and the trunk. The assistant sits on the opposite side of the arm and the instrument nurse at the end of the arm table The whole limb is draped in a roll of sterile stockinet Before rolling the stockinet up the arm the skin around the site of the incision is painted with an adhesive so that the stockinet will adhere to the skin in this region.

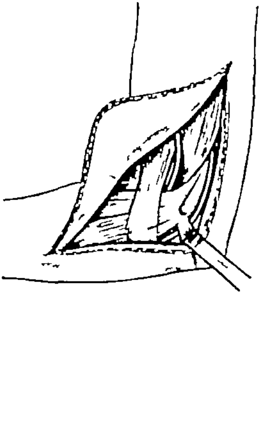


THE OPERATION

The incision

1 An 8-inch incision is made in the line of the ulnar nerve centred at the medial epicondyle

Elevation of skin flaps, identification of ulnar nerve and anterior transposition

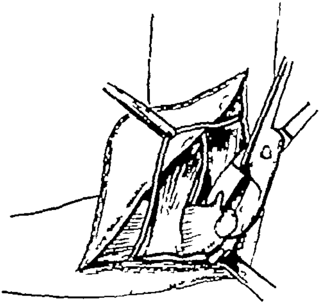


2 The anterior skin flap is elevated by a combination of blunt and sharp dissection. The deep fascia between the flexor and extensor muscles of the upper arm is incised in the line of the ulnar nerve which is sought and identified by blunt dissection. It is identified by its size, direction appearance and texture If there is any doubt it is stimulated using a weak faradic current. Once the nerve has been identified it is followed down to the elbow Here it lies in the groove behind the medial epicondyle. At this point the deep fascia of the forearm is thickened, forming what appears to be a ligament between the medial epicondyle and the olecranon, but it is really only a thickening of the deep fascia between the two heads of the flexor carpi ulnaris. At this point the nerve is rather deep and inaccessible and it is usually advisable to identify the ulnar nerve in the forearm before finally freeing it at the elbow To identify the ulnar nerve in the forearm the deep fascia is incised in the line of the nerve but the nerve itself is identified by blunt dissection The nerve is now freed and held forwards by the assistant. In order finally to free the nerve it may be necessary to sacrifice articular branches to the elbow joint and the upper muscular branch to the flexor carpi ulnaris.

Detachment of medial epicondyle and common flexor origin

3 The medial epicondyle is now detached with bone cutting forceps and the whole epicondyle with the attached common flexor origin is carried forwards, hooking it round the ulnar nerve so as to carry this structure out of danger at the same time. It may be necessary to detach the flexor digitorum sublimis and pronator teres from their ulnar origin.

In order to avoid any risk of damaging the median nerve or brachial artery the knife or raspatory which is used to strip muscles off the bone must be kept very close to the bone

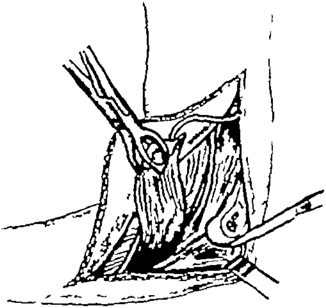


Opening elbow joint

4 The elbow joint is now opened by dividing the medial, anterior and posterior parts of the capsule and any intra-articular adhesions.

Great care must be taken to avoid injuring the median or radial nerves or the brachial artery

In many cases the joint capsule will be adherent to the adjacent muscle. Under such circumstances a radical removal of diseased capsule often cannot be effected with safety although it is desirable to remove as much capsule as possible.



THE OPERATION

The incision

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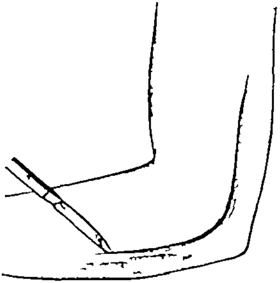
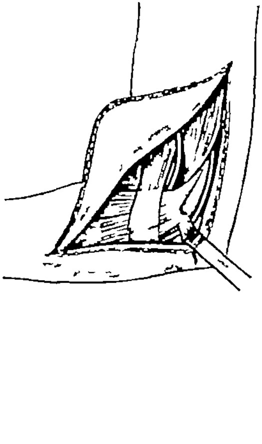
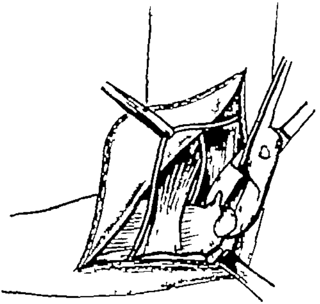


Elevation of skin flaps identification of ulnar nerve and anterior transposition

2 The anterior skin flap is elevated by a combination of blunt and sharp dissection. The deep fascia between the flexor and extensor muscles of the upper arm is incised in the line of the ulnar nerve which is sought and identified by blunt dissection. It is identified by its size, direction, appearance and texture. If there is any doubt it is stimulated using a weak faradic current. Once the nerve has been identified it is followed down to the elbow Here it lies in the groove behind the medial epicondyle. At this point the deep fascia of the forearm is thickened, forming what appears to be a ligament between the medial epicondyle and the olecranon, but it is really only a thickening of the deep fascia between the two heads of the flexor carpi ulnaris. At this point the nerve is rather deep and inaccessible and it is usually advisable to identify the ulnar nerve in the forearm before finally freeing it at the elbow To identify the ulnar nerve in the forearm the deep fascia is incised in the line of the nerve but the nerve itself is identified by blunt dissection. The nerve is now freed and held forwards by the assistant. In order finally to free the nerve it may be necessary to sacrifice articular branches to the elbow joint and the upper muscular branch to the flexor carpi ulnaris.





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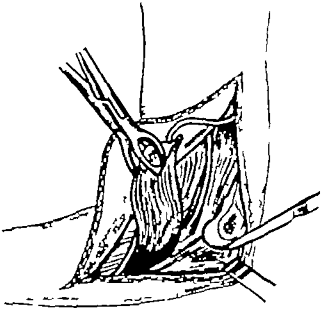


Opening elbow joint

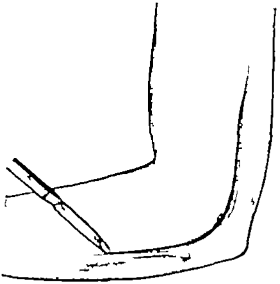
4 The elbow joint is now opened by dividing the medial anterior and posterior parts of the capsule and any intra-articular adhesions.

Great care must be taken to avoid injuring the median or radial nerves or the brachial artery. In many cases, the joint capsule will be adherent to the adjacent muscle. Under such circumstances a radical removal of diseased capsule often cannot be effected with safety, although it is desirable to remove as much capsule as possible.

THE OPERATION

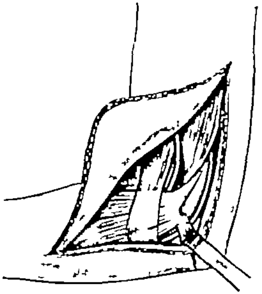
The incision

1 An 8-inch incision is made in the line of the ulnar nerve centred at the medial epicondyle.



Elevation of skin flaps, identification of ulnar nerve and anterior transposition

2 The anterior skin flap is elevated by a combination of blunt and sharp dissection. The deep fascia between the flexor and extensor muscles of the upper arm is incised in the line of the ulnar nerve which is sought and identified by blunt dissection. It is identified by its size, direction, appearance and texture. If there is any doubt it is stimulated using a weak faradic current. Once the nerve has been identified it is followed down to the elbow. Here it lies in the groove behind the medial epicondyle. At this point the deep fascia of the forearm is thickened, forming what appears to be a ligament between the medial epicondyle and the olecranon but it is really only a thickening of the deep fascia between the two heads of the flexor carpi ulnaris. At this point the nerve is rather deep and inaccessible and it is usually advisable to identify the ulnar nerve in the forearm before finally freeing it at the elbow. To identify the ulnar nerve in the forearm the deep fascia is incised in the line of the nerve but the nerve itself is identified by blunt dissection. The nerve is now freed and held forwards by the assistant. In order finally to free the nerve it may be necessary to sacrifice articular branches to the elbow joint and the upper muscular branch to the flexor carpi ulnaris.

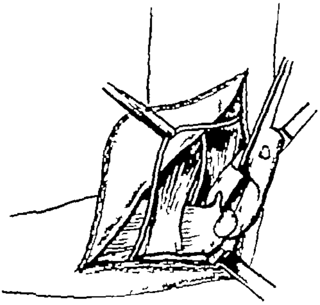


Detachment of medial epicondyle and common flexor origin

3

The medial epicondyle is now detached with bone cutting forceps and the whole epicondyle with the attached common flexor origin is carried forwards, hooking it round the ulnar nerve so as to carry this structure out of danger at the same time. It may be necessary to detach the flexor digitorum sublimis and pronator teres from their ulnar origin.

In order to avoid any risk of damaging the median nerve or brachial artery the knife or raspatory which is used to strip muscles off the bone must be kept very close to the bone.

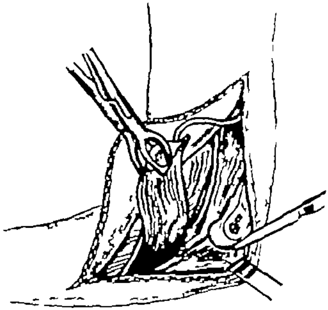


Opening elbow joint

4

The elbow joint is now opened by dividing the medial, anterior and posterior parts of the capsule and any intra-articular adhesions.

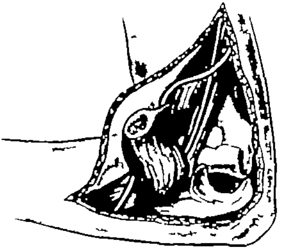
Great care must be taken to avoid injuring the median or radial nerves or the brachial artery. In many cases, the joint capsule will be adherent to the adjacent muscle. Under such circumstances a radical removal of diseased capsule often cannot be effected with safety although it is desirable to remove as much capsule as possible.



Dislocation of elbow

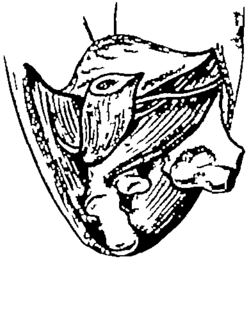
5 During this stage the assistant should gradually increase the carrying angle until finally the forearm comes to lie with its radial border against the radial border of the upper arm and the thumb resting against the greater tuberosity of the humerus.

It is, of course important that the assistant should not use too much force or he may produce a fracture of the ulna or humerus. He should exert sufficient force to put the joint capsule and intra-articular adhesions on the stretch as these are serially divided the hand is slowly approximated to the shoulder



Protrusion of bone ends

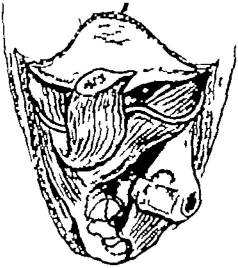
6 The lower end of the humerus and the upper end of the ulna are now projecting out of the wound. As much as possible of the diseased synovial membrane and articular capsule is removed. Portions are sent for histological examination and bacteriological culture, and if tuberculosis is suspected injected into a guinea-pig as well. Great care must be taken not to damage important nerves and blood vessels which may lie close to or even adhere to the joint capsule.



Shaping of lower end of humerus

7 Any remnants of articular cartilage are excised and the lower end of the humerus is shaped into a hemi-cylinder running transversely to the long axis of the humerus in the coronal plane. The coronoid and olecranon processes of the ulna are also trimmed but the central articular portion of the semi-lunar notch is left intact if possible. The dotted lines in the picture represent the line of section of the coronoid and olecranon processes.

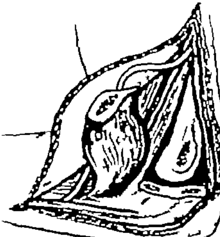
In order to inhibit osteogenesis and re-ankylosis many surgeons pass a diathermy electrode lightly over the raw bony areas.



Reconstruction of joint

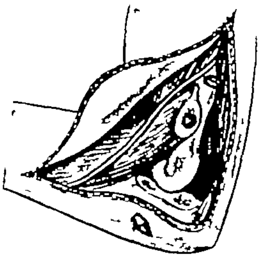
8 The humerus and ulna are now reduced so that they are in a normal relationship but with a gap of 1 – ½ inch between the lower end of the humerus and the articular surface of the ulna when the elbow is flexed some 15 degrees above a right angle.

Maintaining a gap between the bone ends is a more reliable way of preventing re-ankylosis than inserting fascia or dead or foreign material.



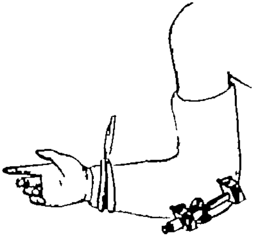
Insertion of Steinmann's pins and upward transplantation of medial epicondyle

9 The easiest way of holding the humerus and ulna in the correct relative positions is to transfix the bones with 3 mm Steinmann's pins inserted transversely in the coronal plane and parallel to each other The pins are joined together by Charnley compression clamps but these are unscrewed so as to produce a slight distracting effect instead of their usual compressing effect. The medial epicondyle with its attached flexor muscles is now re-attached to the bones but not to its previous site. It should be re-attached some $2\frac{1}{2}$ inches farther up the humerus so as to increase their efficacy as flexor muscles of the elbow The normal flexor muscles, the brachialis anterior and the biceps, usually work at a slight mechanical disadvantage after arthroplasty and it is wise to increase the elbow flexing power of the pronator teres and digitorum sublimis. The medial epicondyle is fixed to the humerus by a $1\frac{1}{4}$-inch screw the subjacent bone having been previously rawed. A suitable bed is prepared for the ulnar nerve on the antero-medial aspect of the joint and the skin is then closed without drainage.



Application of plaster

10 Sterile gauze dressings are applied to the wounds and the limb is encircled with a roll of sterile cotton wool from 5 inches above to 5 inches below the elbow joint. This is held in place by two 4-inch crepe bandages which are firmly applied. The tourniquet is then removed. Once the circulation in the fingers has returned to normal a plaster is applied from the axilla to the wrist holding the elbow flexed to 20 degrees above a right angle.



POST-OPERATIVE CARE

This is both very difficult and very important and requires considerable judgment and experience from the surgeon and fortitude and co-operation from the patient. It is well recognized that after any injury or major operation on the elbow peri-articular fibrosis and myositis ossificans may develop. Massage and forced movements aggravate these, therefore mobilization of the elbow after arthroplasty must be gentle and must not commence until the acute reaction to the trauma of operation has subsided. In addition, too early mobilization may lead to lateral instability. On the other hand, too prolonged immobilization may lead to permanent stiffness. Each patient reacts slightly differently. Immediately after operation, static contractions of the biceps and triceps should be commenced and done frequently and regularly. The patient should, of course, have been instructed in these before operation.

At the end of 14 days the plaster is removed and the stitches and the Steinmann's pins are taken out and a new plaster is applied. This is bi-valved during the next week and is removed for half an hour each day for the patient to practise gentle elbow flexion exercises. Provided there is no untoward reaction and the range of movement is improving the period for which the exercises are practised and the forcefulness of the exercises are both slowly increased, but if the elbow becomes swollen or excessively painful, or the patient has a pyrexia, or the range of movement decreases, then this is an indication for resting the elbow. The bi-valved plaster is not finally discarded until there is sufficient muscle development to hold the elbow stable. Forcible manipulation is never indicated in the after-treatment of an arthroplasty of the elbow.

[The illustrations for this Chapter on Arthroplasty of the Elbow were drawn by Mr J. Wheldon from originals by Mr John Aston F.R.C.S.]

Bibliography

Knight, R. A., and Van Zandt, I. L. (1952). *J Bone Jt Surg.*, **34A**, 610.
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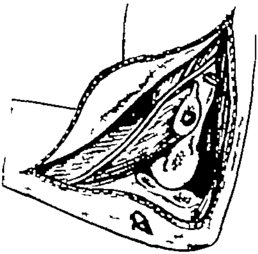

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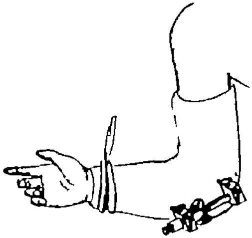

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[*The illustrations for this Chapter on Arthroplasty of the Elbow were drawn by Mr J Wheldon from originals by Mr John Aston F.R.C S*]

Bibliography

Knight, R. A., and Van Zandt, I. L. (1952). *J Bone Jt Surg* **34A**, 610
MacAusland, W R. (1921). *Surg Gynec. Obstet.*, **33**, 223.

ARTHRODESIS OF THE ELBOW

ROBERT ROAF M A F R.C S (ENG.) F R.C.S. (ED), M CH. (ORTH) B.M., B CH., D.R.C.O G

Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry
Lecturer in Orthopaedic Surgery at the University of Liverpool

PRE-OPERATIVE

Indications

The main indications for arthrodesis of the elbow are pain, instability or chronic infective arthritis which is liable to exacerbation. In practice, this means that the main indication is tuberculous arthritis. With early diagnosis and modern treatment, tuberculous arthritis can often be healed leaving a reasonably mobile elbow so that this particular indication is much rarer than it was some years ago Nevertheless, in the presence of gross destruction with caseation and abscess formation, arthrodesis is sometimes indicated. Arthrodesis of the elbow may also be indicated in other forms of infective arthritis and fibrous ankylosis in bad position, in rheumatoid arthritis, degenerative arthritis, old intra-articular fractures, gunshot wounds and old dislocations, if there is marked pain and instability Occasionally arthrodesis of the elbow may be indicated if there is widespread paralysis of the arm but the hand is useful. Usually however it is better to wear a hinged elbow corset which can be locked in a variety of positions according to the need of the moment.

Before deciding on an arthrodesis consideration must be given to the patient's work, age, general condition and temperament. The condition of his other joints must also be considered. If the arthrodesis is to be performed for tuberculous arthritis it is important that there should be no active foci elsewhere in the body and that the arthritis of the elbow be in a quiescent phase. Needless to say full supporting treatment with antibiotics and chemotherapy is essential. It is also important that the shoulder wrist and hand should be as mobile as possible and it may be necessary to spend some time improving the function of these joints before undertaking arthrodesis of the elbow The position of arthrodesis depends on the age and work of the patient and whether it is his right or left arm which is involved. In general, the best position is with the forearm just below the right angle and slightly pronated—that is, the writing position. If possible, the arm should be encased in plaster in various positions before operation so that the patient can judge for himself which position he prefers.

If both elbows are stiff one elbow should be fixed at least 20 degrees above the right angle so as to facilitate the patient getting his hand to his mouth Even so the patient may need to use special long-handled spoons, forks, combs, razors, toothbrushes, etcetera. The other elbow should be fixed at least 25 degrees below the right angle to facilitate writing shaking hands, grasping objects such as door handles, and putting on shoes and stockings.

Contra-indications

The operation is contra-indicated in young children before the epiphyses have fused with the metaphysis. It is also contra-indicated in elderly patients in poor condition or when there has been recent active infection. If a patient is uncertain whether he wishes for an arthrodesis or not it is always possible to provide a removable rigid splint which he can wear for a period to help him to make up his mind.

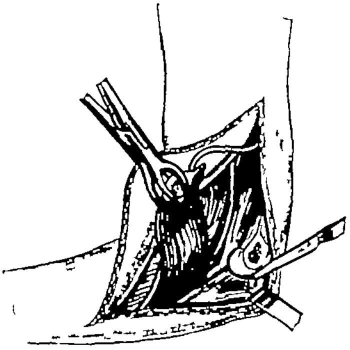
Pre-operative preparation anaesthesia and position of patient

These are the same as for arthroplasty of the elbow (see page 171).

THE OPERATION

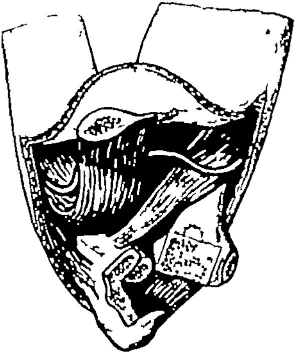
First stages

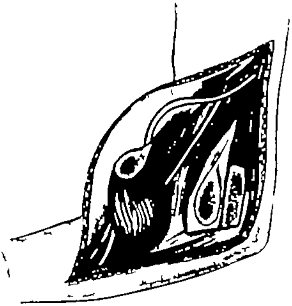
1 The early stages of arthrodesis of the elbow that is incision, elevation of skin flaps, identification and anterior transposition of the ulnar nerve detachment of the medial epicondyle opening the joint and dislocating the joint until the lower end of the humerus and the upper end of the ulna project out of the wound, are the same as for arthroplasty of the elbow (*see* pages 172–178)



Shaping lower end of humerus

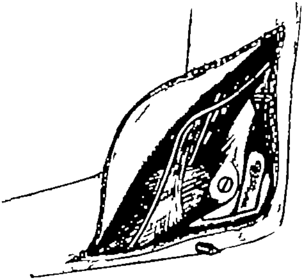
2 All diseased synovial membrane, joint capsule and articular cartilage are removed from the lower end of the humerus and sent for histological examination and bacteriological culture. The lower end of the humerus is then shaped. The exact angles at which the lower raw bone surface meets the anterior and posterior surfaces depends on the angle selected for arthrodesis. In the coronal plane the axis of the inferior articular surface should be at 80 degrees to the long axis of the humerus, that is, a slight carrying angle should be preserved. Any necrotic or caseous foci are lightly curetted attention is then turned to the ulna The articular surfaces of the great sigmoid fossa are then excised so that the anterior and inferior surfaces make an accurate fit with the lower articular surface of the humerus. The superior articular surface of the radius is also denuded of articular cartilage. To assist in this, the assistant supinates the forearm and presses the forearm bones backwards and upwards so that they protrude out of the wound. If the capitellum and the upper end of the radius are shaped so as to fit accurately against each other the elbow is more stable and the chances of rapid bony union are increased. At a later date, if there is firm bony ankylosis between the humerus and the ulna, removal of the head of the radius to restore rotation movement of the forearm may be indicated. Nevertheless, at this stage it is wise to aim at bony union between the humerus and the radius.





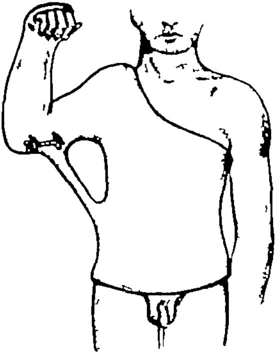
Apposition of humerus and ulna

3 The lower end of the humerus is fitted into the anterior part of the cavity in the ulna. A large block of cancellous iliac bone is now packed into the space between the lower end of the humerus anteriorly and the olecranon posteriorly. This block of cancellous bone should preferably be cut by another surgical team; if this is not possible the surgeon should remove the iliac bone before beginning the operation on the elbow.



Fixation in compression

4 The humerus and ulna are now fixed together in compression by transfixing the lower end of the humerus and the upper end of the ulna with 8-mm. diameter Steinmann's pins. These are inserted transversely into the bones at right angles to the long axis in the coronal plane and parallel to each other when the humerus and ulna are in correct alignment as previously decided. The Steinmann's pins are then joined together by Charnley's compression clamps, ensuring firm contact and compression between the raw bony surfaces. The medial epicondyle is now re-attached using a 1-inch Vitallium screw inserted transversely into the humerus. A suitable bed is prepared for the ulnar nerve anterior to the medial epicondyle and the skin is closed without drainage.



Application of plaster

5 After applying the usual compression dressings and releasing the tourniquet, a thoraco-brachial plaster spica is applied extending from the pelvis to the metacarpal heads.

POST-OPERATIVE

It is essential that the patient should exercise his fingers and thumb from the moment he recovers from the anaesthetic. At the end of 4 weeks the Steinmann's pins are removed but the thoraco-brachial plaster spica is maintained in position for approximately 8 months. At the end of this time there is usually firm bony union but if there is any doubt about the firmness of the union the arm should be put back in plaster this time it need only extend from the axilla to the wrist and the patient can use his arm freely and mobilize his shoulder This plaster is finally removed when firm bony ankylosis can be demonstrated clinically and radiologically

[*The illustrations for this Chapter on Arthrodesis of the Elbow were drawn by Mr John Aston F.R.C S*]

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Molesworth, W H. L (1930). *J Bone Jt Surg.*, 18, 303.
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EXCISION OF THE LOWER END OF THE ULNA

M. S. Brett F.R.C.S.

Senior Registrar The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

The lower end of the ulna may require excision under the following circumstances

(1) When there is pain or loss of rotation of the forearm attributable to derangement of the inferior radio-ulnar joint. The commonest cause is subluxation or dislocation of this joint associated with a malunited fracture of the lower end of the radius.

(2) When there is established non-union of a fracture of the lower third of the shaft of the ulna which is giving rise to symptoms.

(3) When there is a bony abnormality such as chronic osteomyelitis or a tumour confined to the lower end of the ulna.

Anaesthesia

General anaesthesia is recommended.

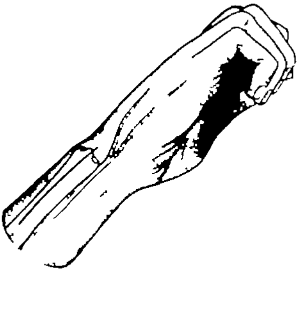
Position of patient

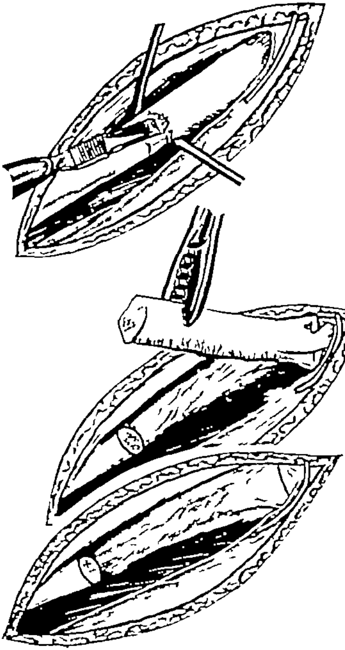
The patient lies supine with the arm resting on a side table. A pneumatic tourniquet is applied to the upper arm.

THE OPERATION

The incision

1 A longitudinal skin incision is made over the subcutaneous surface of the lower third of the ulna. It is approximately 8 inches long and must not extend distal to the styloid process of the ulna because of the danger of cutting the dorsal branch of the ulnar nerve. The deep fascia is incised in the same line.





Stripping of periosteum division of bone

2 The flexor carpi ulnaris and extensor carpi ulnaris are retracted so that the lower end of the ulna is displayed. The site of division of the ulna is chosen about 2 inches above the styloid process. The periosteum is incised transversely round the shaft at this point and the bone is divided cleanly with bone cutters or with a Gigli saw If bone cutters are used it is wise to drill some holes first to avoid splintering of the bone. The sharp edge of the bone should be rounded off with nibblers to avoid leaving any undue subcutaneous prominence.

Removal of bone

3 The dissection of the lower end of the ulna should preferably be extraperiosteal. Some surgeons carry out a subperiosteal resection with seemingly good results, but there is some risk of partial reformation of the bone. The fragment is grasped with bone forceps and dissected free from the radius by cutting through the soft tissue attachments. The dorsal branch of the ulnar nerve may be in danger at this stage and should be retracted out of harm's way

After removal of the lower end of the ulna it should be possible to demonstrate free rotation of the forearm.

The skin alone needs to be sutured.

POST-OPERATIVE CARE AND COMPLICATIONS

A firm crepe bandage is applied over a wool and gauze dressing. The patient is allowed to move the wrist and forearm straight away

There are no special complications. It is said that weakness of the forearm may occur if the ulna is divided above the attachment of pronator quadratus.

[*The illustrations for this Chapter on Excision of the Lower End of the Ulna were drawn by Mr F Price*]

Reference

Dingman, P V C. (1952). "Resection of the Distal End of the Ulna (Darrach Operation)." *J Bone Jt Surg* 34A, 893.

ARTHRODESIS OF THE WRIST

DENIS M. DUNN F.R.C.S.
Orthopaedic Surgeon to the Colchester Group of Hospitals

PRE-OPERATIVE

Indications

Pain in the wrist

Pain in the wrist from degenerative arthritis or traumatic arthritis following injuries to the lower end of the radius or carpal bones which is not relieved by conservative measures is an indication for arthrodesis. This is also true of pain and deformity from rheumatoid arthritis when conservative measures have failed.

Septic arthritis

Septic arthritis, with pain after the infection has subsided, and tuberculous arthritis inadequately controlled as regards the activity of the infection or the pain by local and general rest and by chemotherapy are also indications.

Spastic paralysis with flexion deformity

Occasional cases of spastic paralysis with a flexion deformity of the wrist are improved following surgery. With these patients it may be necessary to extend the wrist much less than usual, otherwise the flexor tendons may be so tightened that the patient is unable to extend the fingers. Careful pre-operative assessment of the optimal functional position is important.

Flaccid paralysis

Some cases of flaccid paralysis as in anterior poliomyelitis and nerve injuries will also benefit from surgical intervention. In complicated palsies the wrist fusion is likely to be but one step in a long reconstruction programme. In some cases of Volkmann's contracture excision of the proximal row of the carpus may be combined with the arthrodesis of the wrist.

The operation should usually include fusion of the inter-carpal joints and of the carpus to the middle metacarpal, as the pathological process is seldom confined to the wrist joint proper. This extension of the operation also allows firm fixation of the bone graft.

Contra-indications

Rheumatoid arthritis during an active stage of the disease is a contra-indication to the operation. Other conditions which exclude arthrodesis are septic arthritis when the infection is still present and very active tuberculosis. (In many cases of tuberculous arthritis it is better to excise affected synovial membrane and curette from the affected areas of the carpus any necrotic foci.)

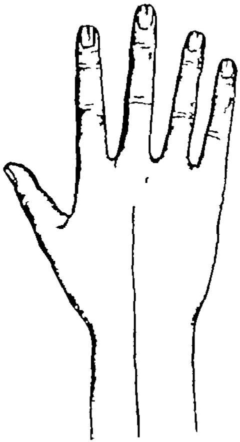
Tourniquet

A bloodless field may be obtained by exsanguinating the limb with a rubber bandage and applying a pneumatic tourniquet to the upper arm.

THE OPERATION

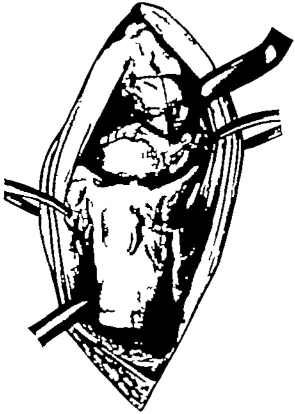
The incision

1 A straight incision is made over the middle of the dorsum of the lower part of the forearm and wrist about 6 inches in length to allow exposure of the distal 2½ inches of the radius and the back of the hand as far as the proximal part of the third metacarpal.
The skin is under-cut, any large veins are secured, and the extensor retinaculum is exposed



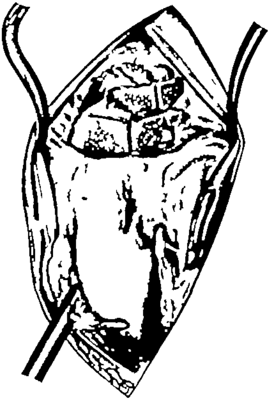
Division of extensor retinaculum and exposure of the tendons

2 The extensor retinaculum is divided longitudinally and dissected off Lister's tubercle and the flaps are turned to each side. The tendons of the extensor pollicis longus and the extensor indicis proprius are retracted to the radial side and the extensor communis to the ulnar side.



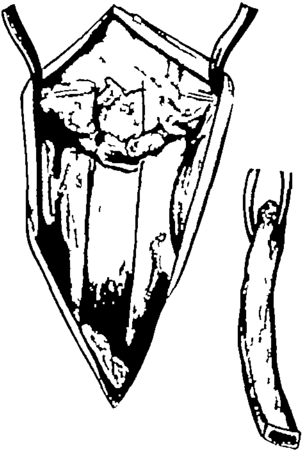
Exposure of the carpus

3 The periosteum over the lower end of the radius is divided longitudinally and reflected with a raspatory. The dorsal capsule of the wrist joint and the posterior ligaments of the carpus are removed by sharp dissection. Great care is taken not to approach or damage the lower radio-ulnar joint.



Removal of the articular cartilage

4 With a gouge the articular cartilage is removed from the distal aspect of the radius and the proximal surface of the scaphoid and lunate bones but not from the triquetral bone. The mid-carpal joint is then denuded by removing the cartilage from the concavity formed by the distal surfaces of the scaphoid, lunate and triquetral bones and from the corresponding convexity of the hamate and capitate bones. As little as possible of the underlying bone is removed. The proximal end of the third metacarpal is exposed.

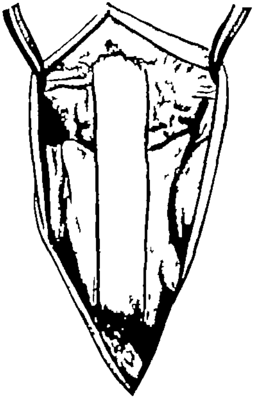


5 Cutting a trough for the bone graft

With a twin circular saw slots are cut just over ½ inch apart in the lowest 2 inches of the radius distally across the back of the carpus as far as the base of the third metacarpal. The intervening bone is removed with a fine osteotome to make a trough. The trough is continued distally as a short tunnel by gouging out a hole in the distal end of the third metacarpal leaving the dorsal cortex of the metacarpal intact. The width of the trough is limited by the need to leave adequate side walls in the end of the radius.

6 Removal of bone graft from ilium

A curved incision is made over the front of the iliac crest and the periosteum and overlying muscles are turned downwards and backwards from the outer surface of the ilium with a raspatory The blades of the twin saw are separated slightly more than they were for cutting the radius, by the thickness of the blades, and a bone graft is cut from the outer cortex of the ilium about 2½ inches long The donor site is carefully selected so that the graft is curved on the flat rather less than the desired amount of extension of the wrist. The graft is cut out of its bed with a generous amount of underlying cancellous bone.

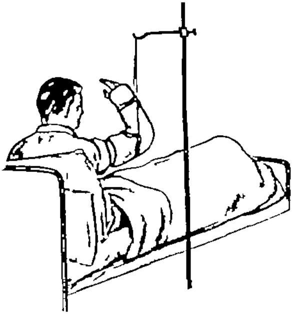


Fixation of bone graft

7 The graft is tried on the wrist for length and curve If it is satisfactory a blunt spike is nibbled on the distal end of the graft and this end is driven into the slot in the proximal end of the third metacarpal. The rest of the graft is embedded in the trough cut in the back of the carpus and radius, and extension of the wrist will keep the graft firmly in place. The small gaps in the carpus are filled with cancellous chips from the ilium.

Closure and external fixation

8 The extensor retinaculum is repaired and the skin closed. In the iliac wound the muscles are firmly sutured again to the iliac crest. Pressure bandages are applied to both wounds, care being taken to keep the wrist extended continuously The final position of the wrist should be in about 25 degrees of extension and neutral adduction-abduction unless the patient's muscle tone or occupation demands some other position. The tourniquet is released. The forearm is then immobilized in a full padded plaster splint from the metacarpal heads to the upper arm with the elbow at a right angle and the forearm in neutral rotation. As the plaster is setting the hand part is carefully moulded and the wrist gently pressed into extension. Plaster loops are fitted by which to suspend the arm.



POST-OPERATIVE CARE

The arm is elevated for the first few days after operation If there is undue swelling of the hand, the plaster and dressings are divided down to the skin.

Finger and shoulder movements are started as soon as the patient is conscious.

The plaster is changed for a lightly padded one and the stitches are removed about two weeks after operation. The splint is finally discarded when clinical and radiographic examination show bony union of the arthrodesis, usually in about three months.

If the pathological process has involved the lower radio-ulnar joint it may be necessary to excise the lowest inch of the ulna to restore rotation of the forearm. It is desirable to start early movements after this procedure, and it is therefore best carried out at a second operation when the wrist is soundly fused.

[*The Illustrations for this Chapter on Arthrodesis of the Wrist were drawn by Mr J Wheldon*]

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OPERATIONS FOR FRACTURE OF THE SCAPHOID BONE

G. L. W. Bonney M.S., F.R.C.S.

Consultant Orthopaedic Surgeon to St. Mary's Hospital and Paddington Green Hospital London Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls Research Assistant to the Institute of Orthopaedics London

PRE-OPERATIVE

Although the subject is a controversial one there is general agreement on the following points (1) all fractures of the tuberosity of the scaphoid bone unite whether immobilized or not therefore operative treatment is never necessary for fractures in this site (2) most fractures of the waist and proximal pole of the scaphoid bone unite if treatment by efficient immobilization is started early (3) the longer treatment of a fracture of the waist or proximal pole of the scaphoid bone is delayed, the greater is the risk of delayed union or non-union and (4) operations which are designed to secure union of a fracture of the scaphoid bone are contra-indicated if arthritis of the wrist joint is already present

Types of operation and their indications

Grafting of the scaphoid

This operation is suitable when a fracture of the waist of the scaphoid bone is treated from the start by efficient immobilization and yet shows at 4 months no evidence of union.

Excision of the proximal fragment of a fractured scaphoid

This operation is indicated when a fracture of the waist of the scaphoid or of its proximal pole is treated from the start by efficient immobilization and shows at 3 months clear radiographic evidence of avascular necrosis of the proximal fragment, without any evidence of revascularization.

Excision of the styloid process of the radius with or without removal of the scaphoid

This procedure is suitable when a fracture of the waist or proximal pole of the scaphoid bone, either through non-union or through long-continued delayed union, is followed by osteoarthritis of the radial compartment of the wrist when the symptoms are mainly localized to the radial side of the joint and are unrelieved by conservative treatment, and when symptoms are not severe enough and the patient's work is not heavy enough to justify arthrodesis of the wrist this operation has a place in treatment.

When the scaphoid is grossly deformed it may be removed at the same time as the radial styloid process is removed, to produce a limited arthroplasty of the wrist.

Arthrodesis of the wrist

This is indicated for osteoarthritis of the wrist as a whole, following non-union or prolonged delayed union of a fracture of the scaphoid for symptoms which are unrelieved by conservative treatment and if the patient is unlikely to be severely handicapped in his occupation by having a fixed wrist.

Special contra-indications

Contra-indications are noted for three of the above operations. For (1) grafting of the scaphoid they are (*a*) non-union with established osteoarthritis (*b*) a very small proximal fragment (*c*) clear evidence of avascular necrosis of the proximal fragment and (*d*) considerable displacement of the fragments (2) excision of the proximal fragment established osteoarthritic changes and (3) excision of the radial styloid process osteoarthritic changes affecting the whole of the wrist joint and causing symptoms related to the whole joint.

Anaesthesia

General anaesthesia is the most satisfactory for all of the following operations. If for any reason it is contra-indicated, regional anaesthesia by brachial block may be used.

For the operations of excision of the proximal fragment, excision of the styloid process of the radius, and arthrodesis of the wrist, a bloodless field is helpful, but it is not necessary for the operation of grafting.

Special instruments

To avoid damaging the blood vessels of the scaphoid by exposure of the whole bone, the technique should be used whereby the graft is introduced through a small incision over the tuberosity. To do this it is necessary to use radiographic control, and to position the wrist so that the long axis of the scaphoid is in the vertical plane and at a right angle to the horizontal plane when viewed from any direction. For this purpose a special rest is used. This rest, conveniently made from wood and aluminium strip, is designed to hold the forearm and hand so that the forearm lies in 45 degrees of supination and at 45 degrees to the horizontal plane. A $\frac{1}{16}$-inch twist drill and a $\frac{}{16}$-inch hollow-cutting trephine are also needed.

Position of patient and arrangement of towels

Grafting of the scaphoid.—After preparation of the skin of the hand and forearm the limb is suitably towelled and placed on an arm-rest of the usual type. The special arm-rest is towelled, and placed so as to be ready for the second stage of the operation.

Excision of the proximal fragment of a fractured scaphoid.—After preparation of the skin and towelling the limb is placed on the arm-rest in a position of pronation of the forearm and of a little ulnar deviation of the wrist.

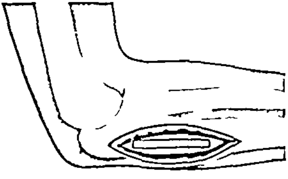
Excision of the styloid process of the radius.—The position assumed here is of mid-pronation of the forearm and of ulnar deviation of the wrist.

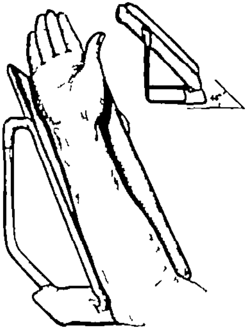
THE OPERATIONS

GRAFTING OF THE SCAPHOID

Obtaining the graft

1 The medial aspect of the upper part of the ulna is exposed through a vertical 2-inch incision placed medial to the subcutaneous border of the bone. A graft about $1\frac{1}{4}$ inches in length and $\frac{}{16}$ inch in width is removed, using either a hammer and chisel or the mechanical saw.

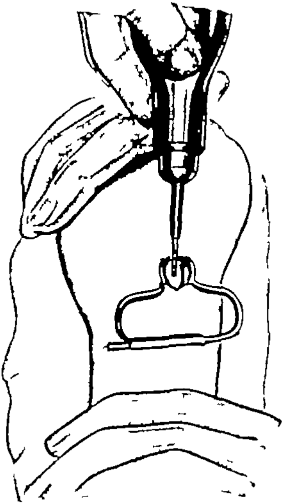




Arm-rest and incision

2 The arm is placed in the special rest and a short incision is made over the tuberosity of the scaphoid. This incision is then deepened down to the bone.

(In order to show the special arm rest the towels are not shown.)

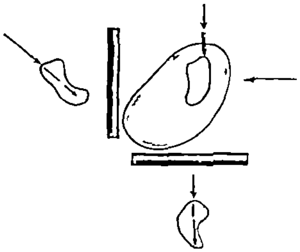


Insertion of drill

3 The $\frac{1}{16}$-inch twist drill is inserted through the small skin incision and, held vertically is gently introduced into the bone. When it has penetrated about 1 inch, radiographs are taken in the lateral and postero-anterior projections.

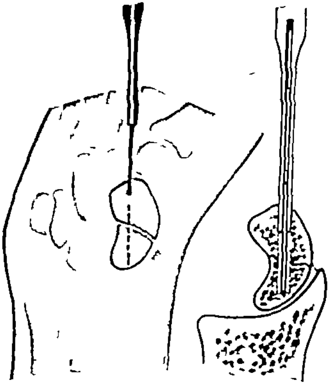
Radiographic projections

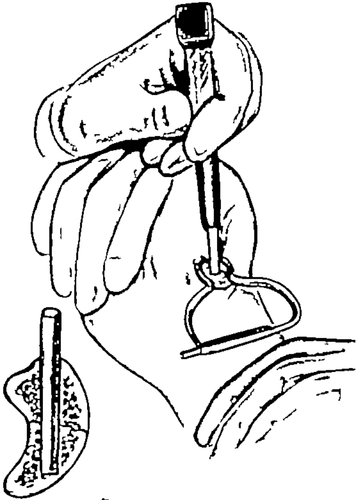
4 In both projections the beam is directed at right angles to the long axis of the forearm. For the lateral view the beam is in the vertical plane and for the postero-anterior view it is in the horizontal plane. If the radiographs confirm that the drill is passing centrally down the bone, the next step can be undertaken. If not, the drill must be withdrawn and re-introduced until the correct position has been obtained.



Insertion of trephine

5 The $\frac{3}{16}$-inch hollow-cutting trephine is introduced over the drill into the bone. The depth of introduction necessary can be calculated from the radiographs. The trephine and drill are later removed.





Insertion of graft

6 The graft, trimmed as necessary is introduced into the tunnel made by the trephine and is punched in until it has entered for the required depth.

The chief difficulties of the operation are those of getting the graft into the correct position and of avoiding breaking the graft during its introduction. In general they can be avoided by careful positioning and by careful preparation of the tunnel for the reception of the graft.

Trimming of graft

7 Radiographs are taken and if these confirm that the graft is in a good position any projecting portion of the graft is cut off and the skin is closed. A padded below-elbow plaster of the "scaphoid" type is applied.

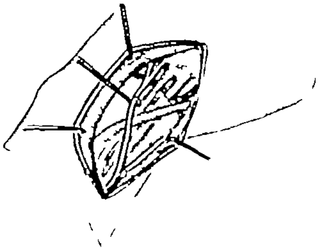
EXCISION OF THE PROXIMAL FRAGMENT OF A FRACTURED SCAPHOID

The Incision

8 The incision is centred over the anatomical snuff box. It is 2 inches long and is slightly curved with the convexity anteriorly

Skin flaps

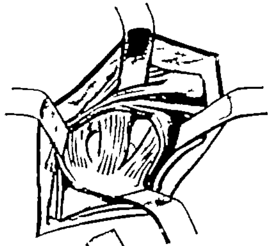
9 The posterior flap is raised and the skin edges are retracted to expose the underlying structures. The terminal part of the radial nerve is exposed at this stage and should be identified and carefully retracted

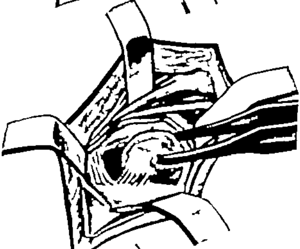


Approach to the scaphoid bone

10 The bone is approached between the tendons of the extensor pollicis longus and the extensor pollicis brevis, after division of the extensor retinaculum. Division of the retinaculum and retraction of the tendons will expose the dorsal capsule of the radiocarpal joint.

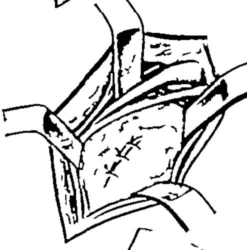
The radiocarpal joint is entered by division of the dorsal capsule and retraction of the cut edges. It is important that the joint should not be traumatized by the introduction of bone levers.





Removal of the proximal fragment

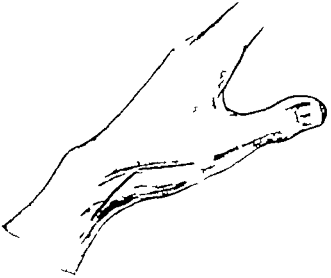
11 The scaphoid bone and its proximal fragment are identified. The proximal fragment is grasped with fine-toothed forceps and its attachments are divided, using a fine-bladed knife. The bone is then removed. Should there be any obvious irregularities of the proximal face of the distal fragment these can be trimmed with fine bone nibblers, but in general it is better to leave the distal fragment alone.



Closure of wound

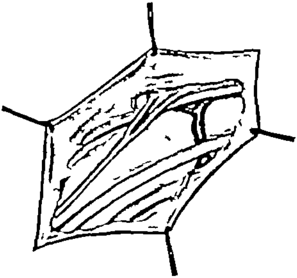
12 The dorsal capsule and the extensor retinaculum are closed with one or two stitches of fine catgut and finally the skin is closed. A padded plaster back slab is applied.

EXCISION OF THE STYLOID PROCESS OF THE RADIUS



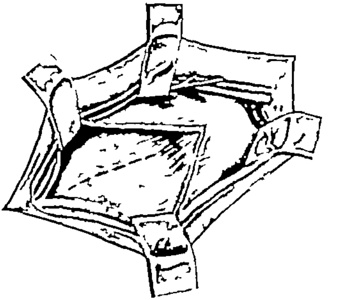
The incision

13 The incision is made over the radial styloid process between the tendons of the extensor pollicis longus and extensor pollicis brevis. It is a straight vertical incision 1½ inches long



Approach to styloid process

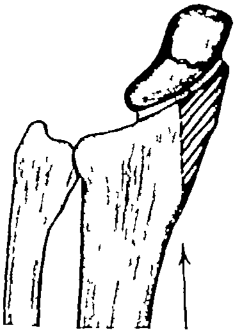
14 The skin edges are retracted and the terminal part of the radial nerve is identified and retracted. The extensor retinaculum is divided and the radial styloid process is approached between the tendons of the long and short extensors of the thumb The radial artery will probably be found crossing the field at this stage and can usually best be retracted forwards. The styloid process is now exposed.



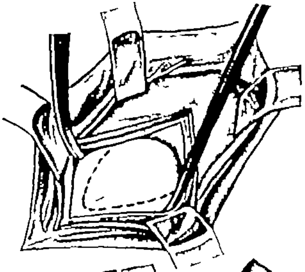
Removal of the bone

Vertical incision of periosteum

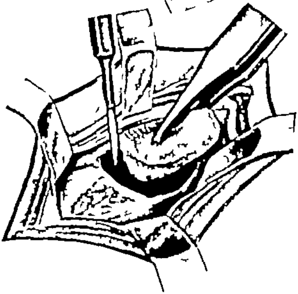
15 The periosteum covering the styloid process is divided by a vertical incision and is elevated from the bone.



16 *Line of bone section*
The line of bone section with the osteotome starts on the lateral border of the radius about 1 inch above its tip and passes almost vertically downwards from this point.



17 *Division of soft-tissue attachments*
The styloid process can now be grasped with forceps and its remaining soft-tissue attachments can be divided. Any projections of bone from the cut surface are removed with the nibblers so that the surface is smooth.



18 Removal of the scaphoid

The scaphoid can be removed at this stage by widening the opening into the joint by further division of the radiocarpal ligaments. The fragments of the bone are exposed, grasped with forceps, freed from their ligamentous attachments and removed.

Closure

The periosteum is brought over the cut surface of the radius, the capsule of the radiocarpal joint is closed if possible with a few stitches of fine catgut, the extensor retinaculum is repaired and the skin is closed. A padded plaster back slab is applied.

POST-OPERATIVE CARE AND COMPLICATIONS

GRAFTING OF THE SCAPHOID

The plaster is retained for 8 weeks, at the end of which time it is removed and the stitches are taken out. A new unpadded plaster is applied and immobilization is continued until radiographs show a satisfactory degree of union of the fracture.

EXCISION OF THE PROXIMAL FRAGMENT OF A FRACTURED SCAPHOID

The plaster is retained for 10–14 days at the end of which time it is taken off and the stitches are removed. Exercises for the wrist are begun, and a good range of movement should be obtained in from 4 to 6 weeks after operation No other special post-operative treatment is needed, though it is a good plan to make a radiological examination of the wrist after operation to make sure that the right piece of bone has been removed.

Special complications

A troublesome complication is the inadvertent removal of the wrong piece of bone—for instance the distal fragment or the lunate bone Should it be found that the distal fragment has been removed it is correct to go on and remove the proximal fragment. Should the lunate bone have been removed it is probably correct to go on and remove the whole proximal row of the carpal bones.

EXCISION OF THE STYLOID PROCESS OF THE RADIUS

The plaster is retained for 10–14 days at the end of which time it is taken off and the stitches are removed. Active exercises for the wrist are begun, and a good range of movement should be attained some 4–6 weeks after operation.

[*The illustrations for this Chapter on Operations for Fracture of the Scaphoid Bone were drawn by Mr R. N Lane*]

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OPERATIONS FOR CONGENITAL DISLOCATION OF THE HIP

J N Wilson ChM., F R C S

Consultant Surgeon The Royal National Orthopaedic Hospital, London

PRE-OPERATIVE

Indications

Open reduction and limbectomy

In selected cases where despite conservative treatment an arthrogram shows that there is an obstruction in the acetabulum causing the femoral head to stand wide out from the joint, or to be lying in the high or low position. An inverted limbus may be seen in the superior part of the acetabulum. The best results for limbectomy may be expected in the age group below 8 years.

Colonna acetabuloplasty

This is indicated in the next age group 3–8 years, where there is complete dislocation, and the femoral head is riding high on the wing of the ilium. The best results are obtained in cases which are unilateral.

Shelf operation

This is indicated in cases where reduction has been obtained, but the head of the femur is showing signs of subluxation, or where the acetabulum is very shallow The operation described is sometimes termed an acetabuloplasty The best results are in the 2–6-year age group In doubtful cases a zone of sclerosis at the supero-lateral margin of the acetabulum is an indication of impending subluxation.

Rotation osteotomy

Where a subluxation is associated with marked anteversion and is corrected by internal rotation of the femur a derotation osteotomy in the subtrochanteric region is indicated. It is used routinely after limbectomy and the Colonna procedure.

Special pre-operative preparation

In cases of open reduction and in the Colonna operation a period of traction is necessary to bring the head of the femur opposite the acetabulum. This is best carried out on a Jones abduction frame Some cases may require tenotomy of the adductors.

If a shelf operation is being considered at the end of a period of conservative treatment, sufficient time must be given to allow the child to mobilize the lower limbs free of fixation and regain full movement in the hips.

Anaesthesia

General anaesthesia is used. Ether is usually favoured in young children. Pentothal given per rectum (1 g per 50 lb. bodyweight in 20 ml. of sterile water) 20 minutes before operation is useful

Towelling and position of patient

With the limb abducted a large towel is drawn up to the groin and around the buttock to above the iliac crest to shut off the perineum The limb is shut off separately so that it can be moved about during the operation.

A 30 degree tilt towards the opposite side is secured by a sandbag under the buttock of the affected side.

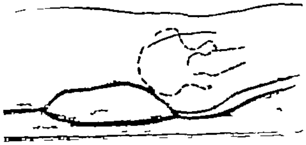
This chapter was prepared by the author while at the Cardiff Royal Infirmary in the Welsh Region.

THE OPERATIONS

OPEN REDUCTION AND LIMBECTOMY

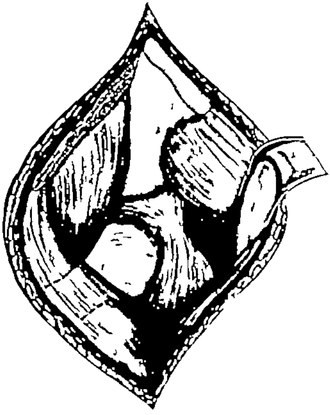
Incision

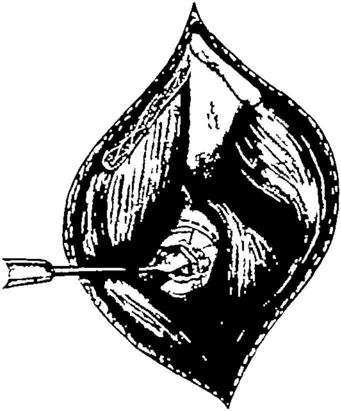
1 The upper two-thirds of the routine Smith-Petersen anterior approach is used. The line of the incision should be about ½ inch lateral to the iliac crest to avoid contracture over the front of the hip



Muscular approach

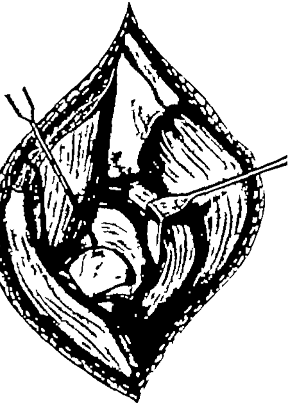
2 The abductors of the hip are separated from the crest of the ilium in the usual way. A pack is placed between the muscle and bone. The tensor fasciae femoris is retracted laterally and the dissection carried between it and sartorius muscle. Branches of the lateral femoral circumflex artery require ligation before the rectus femoris muscle can be displayed and retracted medially to expose the capsule of the hip.





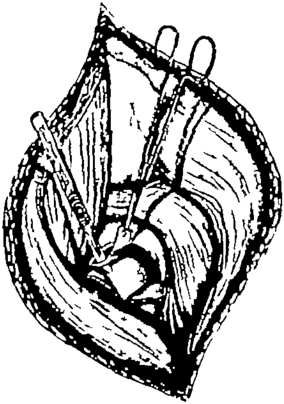
Exposure of capsule

3 The reflected head of the rectus femoris is divided in the postero-superior margin of the acetabulum. This allows a full exposure of the whole of the upper third of the hip. The capsule is exposed by dissection of the fatty tissue over it using a periosteal elevator and a gauze pack. The hip is exposed by an incision along the line of the neck, extended to either side along the acetabular margin. The posterior capsular flap is the larger in order to allow free access to the posterior part of the hip



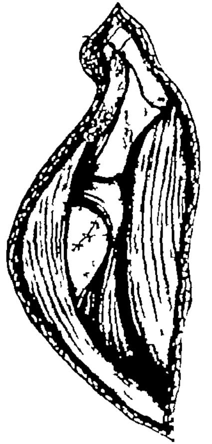
Exploration of acetabulum

4 By putting traction on the lower limb the head of the femur may be drawn down and the upper and posterior lip of the acetabulum visualized. *A blunt hook is inserted into the* hip under the superior lip and if there is an inverted limbus present the hook will be felt to catch under its free margin, rather like hooking the edge of a meniscus in the knee The obstruction may be narrow and resemble a knee cartilage closely or may extend half way across the joint as a large plaque. If limbectomy alone is the intention the hip should not be dislocated. Sufficient exposure can be obtained by traction Dislocation should only be carried out if it is thought necessary to remove soft tissue obstructions from the middle of the acetabulum.



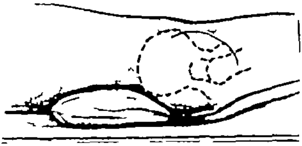
Excision of limbus

5 Removal is started with a knife, but the posterior half must be removed blind and is best carried out using Mayo scissors. A Smillie cartilage knife may be useful in detaching the superior portion. The obstruction to reduction by the limbus is more posterior than superior and it is essential to remove all the posterior part to allow perfect reduction. The test of adequate removal is that the head of the femur should sink deeply into the acetabulum on internal rotation.



Closure

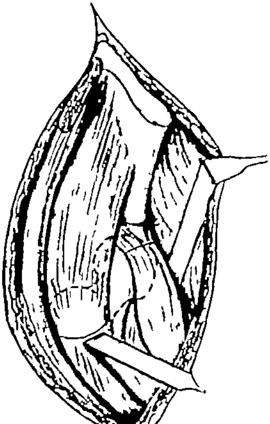
6 With the head of the femur in full internal rotation the capsule is repaired by a few separate sutures of No 1 catgut. The abductor muscles are sutured back to the iliac crest and the skin closed by interrupted sutures. The limb is immobilized in a single plaster spica with the hip slightly abducted and fully internally rotated.



COLONNA ACETABULOPLASTY

Incision

7 The skin incision extends from a point 2 inches behind the anterior superior spine of the ilium, curving downwards and backwards to another point 2 inches below the tip of the greater trochanter

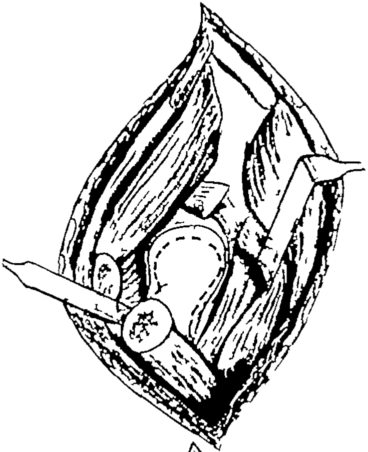


Muscle approach

8 The tensor fascia femoris muscle and the fascial layer posteriorly are incised in the line of the skin incision. Dissection is carried between the sartorius and tensor muscles and the latter separated from the iliac crest. The whole muscle may then be turned outwards and backwards with the skin flap. The greater trochanter and insertion of the gluteal muscles is then exposed. The anterior and posterior margins of this insertion must be defined by blunt dissection in a layer of fatty tissue It may be necessary to ligate several vessels in this area which pass across to the muscle belly of tensor fascia femoris. The tip of the greater trochanter is osteotomized and the gluteal muscles turned upwards. The capsule of the hip may be fully exposed by division of the origin of the rectus femoris along the line shown.

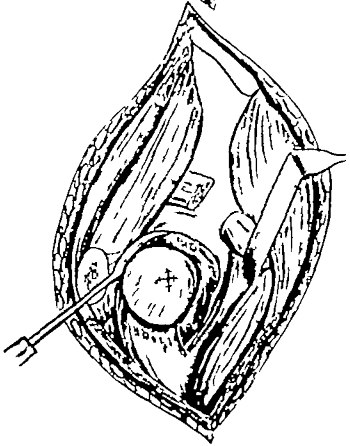
Dissection of the capsule

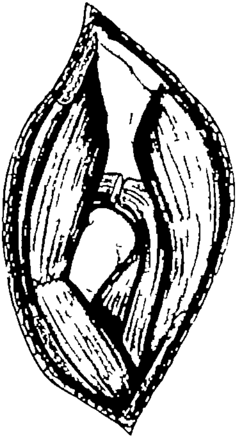
9 The capsule must be clearly defined anteriorly superiorly and posteriorly Dissection is carried out around the line shown. It is best performed by using Mayo scissors as the capsule will have to be cut away from the rectus femoris reflected head and from the ilium and upper lip of the acetabulum. It is essential to continue the dissection until the "hour-glass" constriction can be demonstrated, because it is only then that it is certain that there will be sufficient capsule to cover the head of the femur completely This part of the operation is the most difficult, and it is to be remembered that the constriction is situated very much more medial and inferior than would be expected.



Suture of capsule and deepening of acetabulum

10 The capsule is divided at the constriction and after inspection of the femoral head the hour-glass constriction of the capsule is sutured to enclose the head completely By external rotation and by applying traction to the limb the acetabulum may be easily exposed and cleared of any soft-tissue obstruction. It is then deepened using goose-neck gouges. All the shaping of the new socket must be done with gouges the average hip reamer is much too large to be of any use. A very deep acetabulum should be made. It is better to be too deep than too shallow and it does not matter if the inner pelvic cortex is pierced. The site of the new acetabulum should be as near to the normal as possible compatible with easy reduction of the femoral head.





Closure

11 The capsule covered head of femur is turned into the deepened acetabulum. It is usual to put the limb up in a little abduction and full internal rotation in order to obtain good stability If it is necessary to abduct to a marked degree to maintain stability it is an indication that the acetabulum is not deep enough. The greater trochanter is repaired with catgut sutures and the origin of rectus femoris re-attached. The tensor fascia femoris is repaired in the line of the skin incision. A single plaster spica is applied with the limb immobilized to the toes in full internal rotation and slight abduction.

THE SHELF OPERATION

Incision and muscle approach

12 This is the same procedure as for the operation of open reduction.

Preparation of the shelf

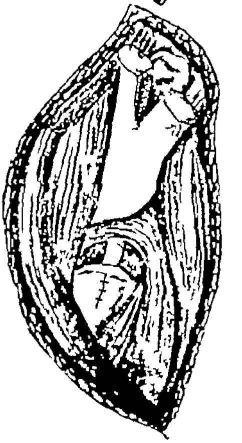
13 The shelf is to be turned down from the superior margin of the acetabulum and should measure about one-third of its circumference. This is usually about $1\frac{1}{4}$ inches in width in the young child. The capsule of the hip is opened by making two flaps as shown. These flaps should be of sufficient size to allow the rim of the acetabulum to be visualized along the whole length of the proposed shelf. Osteotomy is performed about $\frac{3}{4}$ inch above the rim. A straight osteotome is used to start the cut, but it is continued with a small goose-neck osteotome which follows the acetabular roof.

Formation of the wedge

14 The osteotomy is made to the depth of 1 inch and gradually a wedge is opened up by depression of the handle of the osteotome. It is sometimes easier to use two straight osteotomes to carry out this manoeuvre. It is opened up to $\frac{1}{4}$ inch. The inner side of the wing of the ilium is cleared of muscle and a swab pushed down between bone and muscle to expose the rim of the ilium. A wedge of bone of $\frac{1}{4}$-inch width and depth is cut as shown. It is inserted into the middle of the site of osteotomy, a slot having been prepared in the upper margin to receive the upper limb of the wedge. This is a very essential step in the operation to prevent the wedge turning on its side. The space to either side of the master wedge may be packed with bone chips, but only one piece of bone is used to maintain the osteotomy apart.

Closure

The capsule and wound is closed as in the operation for open reduction. A single plaster spica is applied immobilizing the limb as far as the toes and with the hip in 20 degrees abduction (see Illustration 6 on page 203)



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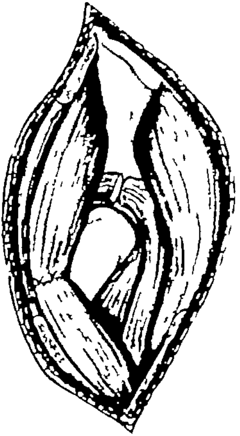

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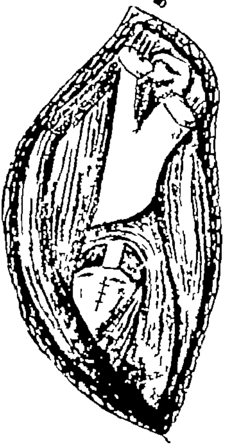

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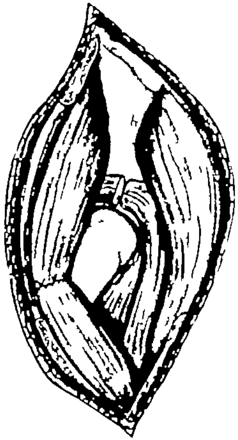

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Incision and muscle approach

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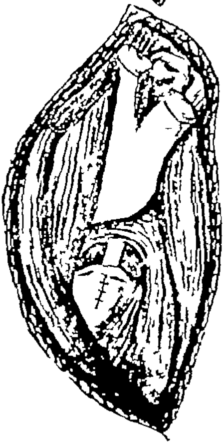

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Closure

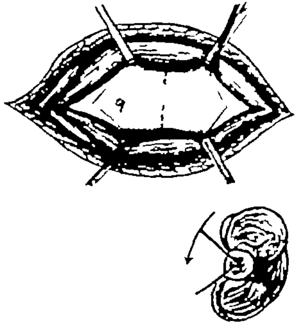
The capsule and wound is closed as in the operation for open reduction. A single plaster spica is applied immobilizing the limb as far as the toes and with the hip in 20 degrees abduction (see Illustration 6 on page 203)

ROTATION OSTEOTOMY

Site, osteotomy and rotation

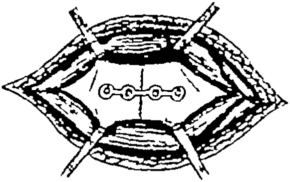
15 The usual site for the osteotomy is subtrochanteric, but in certain circumstances a supracondylar osteotomy is indicated—after a Colonna operation. This site has the disadvantage that knee movement is slow to return, probably due to the twist put on the extensor mechanism.

The incision and muscle approach is as for *any subtrochanteric osteotomy* of the femur. At this age the periosteum may be incised as a definite layer and levers may be passed round the medial surface subperiosteally. The bone should be cut through about 2½ inches below the tip of the greater trochanter. Before osteotomy is performed two drills are inserted above and below set at an angle to each other equal to the amount of rotation necessary to correct the anteversion (*see* inset). The longitudinal distance between them is equal to distance between the furthermost holes of the plate to be used for fixation of the osteotomy. Osteotomy of the femur is carried out with a thin-bladed osteotome, the structures on the medial side being guarded by a bone lever. The lower fragment is externally rotated until the two drills are parallel. The upper fragment is kept fully internally rotated.



Fixation and repair

16 A four-hole Vitallium plate is used for internal fixation of the osteotomy. It should be 2½–3 inches in length and have a long middle segment to allow the nearside screws to be well away from the osteotomy site. The plate may be placed over the two drills while the nearside screws are inserted. This prevents any loss of rotation while the plate is being applied. The outermost drill holes can then be completed and the plate screwed home. The closure of the muscles is by continuous catgut sutures in two layers. The skin closure is in the usual way. A single plaster spica is applied with the limb in the neutral position.



POST-OPERATIVE CARE

OPEN REDUCTION AND LIMBECTOMY

The anteversion deformity of the head and neck of the femur is nearly always present and must be corrected at a second stage operation. This is carried out 4 weeks after limbectomy or simple open reduction. This operation is followed by 8 weeks further plaster spica fixation After the removal of the cast there is often some abduction deformity of the hip This should be treated by gradual mobilization in bed for some weeks. Weight bearing is deferred for 4 weeks. If bilateral operations are necessary they can be carried out at the same session.

Complications

Avascular necrosis may occur in some cases. It is said to be very unusual in cases where the exposure has been limited and the head of the femur has not been dislocated. Further subluxation may occur and serial radiographs should be taken following removal of the plaster Sudden onset of pain and stiffness in the joint may be an indication of this complication. If subluxation does occur a shelf operation may be necessary if stability is not obtained by another period in an abduction plaster

COLONNA ACETABULOPLASTY

Blood transfusion may be necessary during or after the operation. A derotation osteotomy is carried out 2 weeks later at the supracondylar level in order to allow the hip to be liberated for mobilization while the osteotomy is still consolidating The plaster spica is changed to an above knee cast after 8 weeks. This is maintained for another 8 weeks, but during this time the hip is exercised. It is important to maintain a position of slight abduction when at rest and this is most easily obtained by putting a pillow between the legs Weight bearing is deferred for at least 8 months from the time of the osteotomy A pattern-ended caliper may be useful in this respect.

During this early stage of mobilization attention must be given to any spasm in the hip If this develops no attempt should be made to force motion, but the child put to bed with traction on the affected side until the stiffness disappears. Avascular necrosis of the head of femur may occur but is rare if no force has been used in reduction. *A hip skid should never be employed.*

In bilateral cases operation on the second side should be deferred until the first side has regained mobility

THE SHELF OPERATION

The single plaster spica is maintained for 8 weeks. The cast is then removed, the child re-radiographed, and usually the hip is mobilized if possible. If there is a marked anteversion deformity of the head of the femur it may be necessary to carry out a de-rotation osteotomy after a short period of exercises to allow restoration of hip movement. Weight bearing should be deferred for at least 4 weeks after the child comes out of plaster

A radiograph should be taken immediately after the operation to see if there is sufficient abduction to allow the head of the femur to be well under the shelf If necessary the plaster should be changed to increase the abduction to the required amount. If both sides are to be operated upon there should be at least a month between operations.

ROTATION OSTEOTOMY

The single spica is maintained for 8 weeks. Radiographs are then taken with the limbs out of plaster and if sufficient degree of union is present the child is allowed to mobilize the hip If both hips require to be corrected a month should elapse between operations. When the child starts to walk he will adopt an external rotation gait. This should quickly disappear If it does not, or if the external rotation is grotesque, then further radiographs should be taken in varying degrees of rotation to be sure that the hip is not subluxating again.

[*The illustrations for this Chapter on Operations for Congenital Dislocation of the Hip were drawn by Mr J Wheldon from originals by Mr J N Wilson*]

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OPERATIONS FOR SLIPPED UPPER FEMORAL EPIPHYSIS

J. N. WILSON, CH.M., F.R.C.S.
Consultant Surgeon, The Royal National Orthopaedic Hospital, London

PRE-OPERATIVE

Operations

(1) Closed reduction and nailing, (2) open reduction by osteotomy and nailing, and (3) corrective subtrochanteric osteotomy. Only the latter two procedures are described in this Chapter.

Indications

Reduction and nailing

This is indicated only in cases of acute slip where reduction can be easily carried out by an internal rotation and traction manoeuvre, or where the epiphysis can be nailed *in situ*. The nailing is carried out by the usual technique of Smith-Petersen, described on page 201.

Open reduction by osteotomy and nailing

This is indicated in the acute slip which has been left too long to allow *easy* manipulative reduction, or in the chronic slip where the epiphysis has displaced too far to allow nailing *in situ*.

Corrective subtrochanteric osteotomy

This is indicated in cases where a severe slip has remained undetected for some time and where there is a well-established buttress of bone on the under side of the neck of the femur. Correction is obtained by abduction and rotation at the osteotomy site.

Radiological examination

True antero-posterior and lateral radiographs of both hips must be obtained. It should be remembered that the hip on the apparently normal side may show some degree of displacement and require nailing *in situ*.

Special pre-operative preparation

In cases of acute slip it is sometimes possible to obtain reduction of the deformity by traction and internal rotation on a Dunn-Hendry sliding bed. This is a gradual reduction and if it can be produced is less likely to result in an avascular necrosis of the epiphysis.

Anaesthesia

A routine general anaesthetic is used.

Position of patient

A 30 degree tilt towards the opposite side is secured by a sandbag under the buttock of the affected side. If a nailing procedure is to follow an open reduction, the operation must be performed on an orthopaedic table.

Towelling

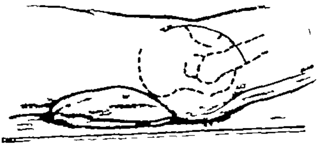
The system of towelling is the same as for operations for congenital dislocation of the hip. The arrangement must allow complete freedom of the limb for any necessary manipulation.

This chapter was prepared by the author while at the Cardiff Royal Infirmary, in the Welsh Region.

OPEN REDUCTION OF SLIPPED UPPER FEMORAL EPIPHYSIS

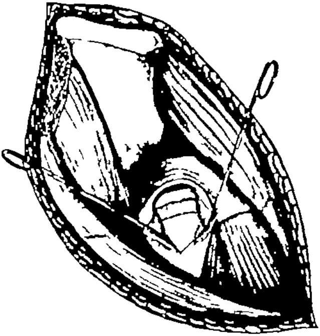
Incision

1 The ordinary Smith-Petersen anterior approach is continued downwards and backwards to a point 2-3 inches below the tip of the greater trochanter The lower part of the incision need not be made until the stage of insertion of the Smith-Petersen nail. A Watson-Jones approach can be used, and has the advantage that the nailing can be easily carried out by extension of the lower limb of the incision. It gives a very limited exposure of the head and neck of the femur and for that reason the more extensive anterior approach is advised.



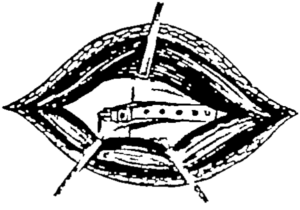
Incision of capsule and site of osteotomy

2 The capsule is exposed in the usual way by separation of the gluteal muscles from the iliac crest and dissection between tensor fascia femoris and sartorius. The capsule is incised along the line of the neck and the hip joint opened by carrying the incision to either side along the rim of the acetabulum. The edge of the epiphysis and articular surface of the femur will be seen as a thin crescent, and the site of slip will be seen as an area of irregular surface, bluish in colour and covered with tense periosteum In a very recent slip the actual raw surface may be visible from which the femoral head has displaced. The site of commencement of the osteotomy is shown in the drawing The osteotome should be inserted about ¼ inch distal to the edge of the epiphysis, the bone being cleared of periosteum and fibrous tissue before osteotomy is attempted.



Fixation and closure

7 A five-hole plate is now bolted to the projecting nail the Steinmann pin having been removed. Because of the abduction at the osteotomy site the nail and plate will now be articulating at their most oblique angle. The plate is screwed on to the distal fragment. The closure is by continuous catgut suture for the muscle layers and simple skin suture. No form of splintage is necessary



POST-OPERATIVE CARE

OPEN REDUCTION OF SLIPPED UPPER FEMORAL EPIPHYSIS

The operation is a severe one and blood transfusion will probably be necessary either during or shortly after it. The patient is allowed to move the hip and knee freely within the limits of the traction, which should be maintained for 4 weeks. *If further radiographs are satisfactory the traction may be discontinued then, and the patient allowed* more freedom of movement. No weight bearing should be considered for at least 3 months from the time of operation, and then the decision to allow weight to be taken must be governed by the radiographic appearance and clinical condition. Signs of avascular necrosis and increasing stiffness are indications that the patient should continue non-weight bearing

Repeated radiographic follow-up is essential for 2–3 years after operation Increased density of the head of the femur in the early months is an indication of avascular necrosis. This complication is indicated later by crumbling of the epiphysis. In all cases the epiphysis should fuse a few months after the operation, so that further slipping is only possible in the rare eventuality of the nail becoming disengaged.

OSTEOTOMY FOR SLIPPED EPIPHYSIS

The patient should remain non-weight bearing for at least 6 weeks after operation. He should then be allowed to bear weight with crutches until the osteotomy is radiologically sound. He is encouraged to perform active exercises of the hip and knee throughout the post-operative period.

Monthly radiographic checks should be made and if union of the osteotomy seems to be delayed the hip should be immobilized in a single long hip spica. Sudden pain or spasm in the hip may be an indication that the nail-plate has come apart, or that there is strain at the site of osteotomy—possibly from weight bearing too early or too strenuous exercises.

[*The illustrations for this Chapter on Operations for Slipped Upper Femoral Epiphysis were drawn by Mr J Wheldon from originals by Mr J N Wilson.*]

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OSTEOTOMY OF THE UPPER END OF THE FEMUR

O J VAUGHAN-JACKSON V R.D., B.M., B CH. (OXON), F.R.C.S
Orthopaedic Surgeon, the London Hospital Consultant in Orthopaedics to the Royal Navy

PRE-OPERATIVE

Indications

Osteotomy for correction of deformity

Simple angular deformities—Infantile coxa vara, coxa valga malunited fractures of the femoral neck and trochanteric region ankylosis of the hip in bad position arthrodesis of the hip in which a bad position, usually abduction, has been deliberately accepted in order to facilitate bony fusion, the need for a subsequent corrective osteotomy being foreseen and accepted. These are suitable for either transverse osteotomy with the opening-out of a wedge, or cuneiform osteotomy with closure of the angle.

Rotation deformities—Congenital dislocation of the hip to correct anteversion of the femoral neck cerebral palsy (spastic) to compensate for uncorrectable spasm of the internal rotators of the hip

Osteotomy for shortening the femur

Operations for rotation deformities and for femoral shortening are generally simple transverse osteotomies, completed by internal fixation, bone plate blade plate or similar means.

Osteotomy for altering the line of weight-bearing or promoting bony union

Osteotomy as a step in arthrodesis of the hip—Examples of such arthrodeses are extra-articular ischio-femoral arthrodesis (Brittain) intra articular arthrodesis (Pyrford)

Osteotomy as (1) a primary procedure, and (2) a secondary procedure in the treatment of osteoarthritis of the hip

Osteotomy for ununited fractures of the femoral neck

These operations for altering the line of weight-bearing or promoting bony union are with the exception of (2) above, the displacement type of osteotomy of McMurray In (2) a Batchelor type is often used. This is a high-shaft abduction osteotomy Combined with an excision of the osteo-arthritic head and neck of femur it produces a "shoulder" on which the empty acetabulum can rest during weight-bearing It is, of course an arthroplasty (see page 215) The Schanz osteotomy provides a similar shoulder in irreducible congenital dislocation of the hip

Special contra-indications

These are few The presence of infection anywhere may result in secondary infection of the osteotomy

Special equipment or apparatus

Radiographic control in the theatre is essential. A cassette-holding bridge under the buttocks is very desirable.

Pre-operative preparation

The patient's blood group is assessed and suitable blood is made available for transfusion. Thorough three-day skin preparation is usual.

Anaesthesia

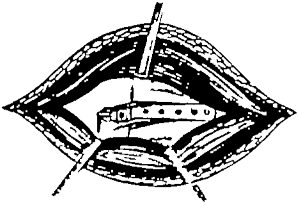
Routine endotracheal general anaesthesia usually suffices. Hypotensive methods should not usually be necessary but may be desirable where the osteotomy is merely a part of a larger procedure.

Position of the patient

The supine position is usual, on an orthopaedic table, since a plaster spica has usually to be applied.

Fixation and closure

7 A five-hole plate is now bolted to the projecting nail the Steinmann pin having been removed. Because of the abduction at the osteotomy site the nail and plate will now be articulating at their most oblique angle. The plate is screwed on to the distal fragment. The closure is by continuous catgut suture for the muscle layers and simple skin suture. No form of splintage is necessary



POST-OPERATIVE CARE

OPEN REDUCTION OF SLIPPED UPPER FEMORAL EPIPHYSIS

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OSTEOTOMY OF THE UPPER END OF THE FEMUR

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PRE-OPERATIVE

Indications

Osteotomy for correction of deformity

Simple angular deformities.—Infantile coxa vara, coxa valga malunited fractures of the femoral neck and trochanteric region ankylosis of the hip in bad position arthrodesis of the hip in which a bad position, usually abduction has been deliberately accepted in order to facilitate bony fusion, the need for a subsequent corrective osteotomy being foreseen and accepted. These are suitable for either transverse osteotomy with the opening-out of a wedge, or cuneiform osteotomy with closure of the angle.

Rotation deformities.—Congenital dislocation of the hip, to correct anteversion of the femoral neck cerebral palsy (spastic) to compensate for uncorrectable spasm of the internal rotators of the hip

Osteotomy for shortening the femur

Operations for rotation deformities and for femoral shortening are generally simple transverse osteotomies, completed by internal fixation, bone plate blade plate or similar means.

Osteotomy for altering the line of weight-bearing or promoting bony union

Osteotomy as a step in arthrodesis of the hip.—Examples of such arthrodeses are extra-articular ischio-femoral arthrodesis (Brittain) intra-articular arthrodesis (Pyrford)

Osteotomy as (1) a primary procedure, and (2) a secondary procedure in the treatment of osteoarthritis of the hip

Osteotomy for ununited fractures of the femoral neck

These operations for altering the line of weight-bearing or promoting bony union are with the exception of (2) above, the displacement type of osteotomy of McMurray In (2) a Batchelor type is often used. This is a high-shaft abduction osteotomy Combined with an excision of the osteo-arthritic head and neck of femur it produces a "shoulder" on which the empty acetabulum can rest during weight-bearing It is, of course, an arthroplasty (*see* page 246) The Schanz osteotomy provides a similar shoulder in irreducible congenital dislocation of the hip

Special contra-indications

These are few The presence of infection anywhere may result in secondary infection of the osteotomy

Special equipment or apparatus

Radiographic control in the theatre is essential. A cassette-holding bridge under the buttocks is very desirable.

Pre-operative preparation

The patient's blood group is assessed and suitable blood is made available for transfusion. Thorough three-day skin preparation is usual.

Anaesthesia

Routine endotracheal general anaesthesia usually suffices. Hypotensive methods should not usually be necessary but may be desirable where the osteotomy is merely a part of a larger procedure

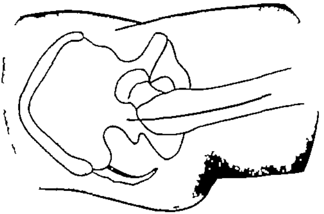
Position of the patient

The supine position is usual, on an orthopaedic table, since a plaster spica has usually to be applied.

THE OPERATION

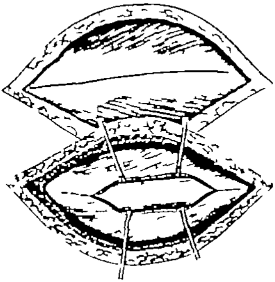
The incision

1 The incision is made from the prominence of the greater trochanter downwards, on the lateral aspect of the thigh, in the line of the femoral shaft for usually not more than 6 inches. This exposes the glistening fascia lata and its tensor muscle



Method of exposure

2 The fascia lata and tensor are split longitudinally in the line of their fibres and the edges retracted. This exposes the fibres of vastus lateralis running obliquely forwards and distally These can be separated for a short distance by blunt dissection down to the bone A pair of closed straight Mayo scissors is a useful dissector Spike retractors with curved blunt points are then passed in front of and behind the femoral shaft in the subtrochanteric region and their handles held apart. The separation of the vastus fibres that this produces is then completed upwards and downwards as far as necessary by a touch or two of the knife. Additional exposure is obtained by clearing the muscle fibres from the lateral surface of the femur for an inch or two with a periosteal elevator No important blood vessels are encountered and haemostasis is secured by diathermy or haemostasis and ligation, as necessary

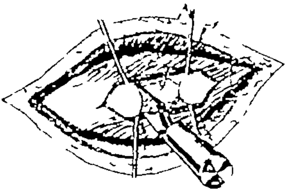


Division of the femur

Level

3 In the displacement osteotomy the object is to get the upper end of the lower fragment displaced inwards under the femoral head and neck, and even under the lower margin of the acetabulum. The osteotomy therefore is high and is intertrochanteric. Most other osteotomies are subtrochanteric—sometimes (Schanz) they are "high-shaft osteotomies" The approach described serves for either group The outward curve of the femoral shaft as it runs up to the prominence of the greater trochanter is the landmark, and comparison of this with radiographs allows one to place and align the osteotome by eye with considerable precision, but nevertheless a check antero-posterior radiograph is essential before proceeding

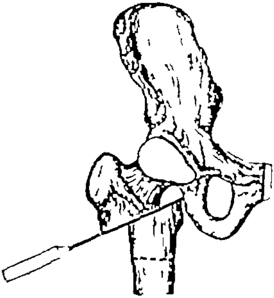
An osteotome as wide as the diameter of the femoral shaft is desirable. A heavy metal mallet is essential and it is wiser to withdraw the osteotome frequently while cutting through the cortex of the femur in front and behind. (It is embarrassing using too small an osteotome, to penetrate the femur without severing it, and then to be unable to withdraw the instrument.)



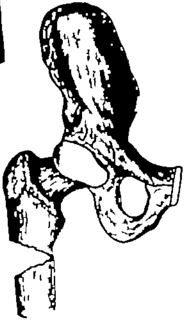
Shape and direction of cut

4 This may be either linear or cuneiform.

Linear.—(1) In the displacement osteotomy the cut is usually obliquely upwards and inwards aiming at the ischium at the lower border of the acetabulum. It is necessary to remember the proximity of the sciatic nerve posteriorly and direct the osteotome accordingly (2) In subtrochanteric osteotomies the cut is usually at right angles to the shaft. In the Lorenz bifurcation osteotomy not very frequently used today it is oblique.



5 *Cuneiform simple deformity*.—If the deformity is a simple angular one such as a fixed flexion deformity the wedge is simply disposed with its apex anteriorly and base behind.

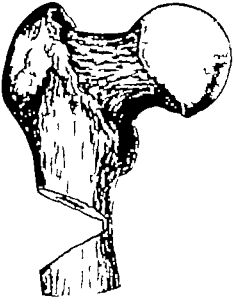


6 *Cuneiform compound deformity*.—If the deformity is, say a flexion adduction deformity that is, a compound deformity the wedge also is compound with its apex antero-medially and base postero-laterally The appropriate wedge needs shaping with great care The wedge is removed either by the osteotome alone or more usually with bone-nibbling forceps as well.

In shortening the femur.—Two transverse osteotomies appropriately spaced, or a step cut, are used. The latter is a special procedure outside the scope of this chapter

OSTEOTOMY OSTEOCLASIS

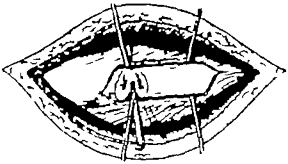
This valuable technique, advocated by J Royal Moore of Philadelphia, simplifies the operation by rendering unnecessary much of the above three-dimensional calculation. It is *not* applicable to the displacement osteotomy but only to osteotomy for angular correction.



First stage

7 *Removal of wedge*.—The osteotomy is planned exactly as above but is carried out in two steps. In the first the wedge is removed (best by means of bone nibblers) as far as but not through the cortex at the apex. Here a thin bridge of bone is left intact.

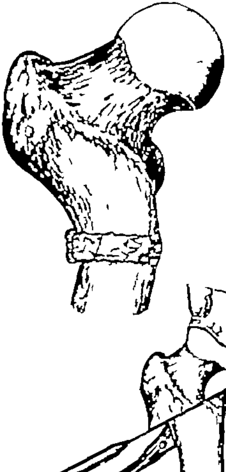
8 *Drilling of bony bridge*.—The remaining bridge of bone can be further prepared for the osteoclasis later by drilling one or two holes through it. The bone fragments nibbled away are replaced in the wedge, the wound closed, and the limb immobilized in a plaster spica, *still in the position of deformity*.



Second stage

9 The second stage is carried out after three weeks by which time healing will have progressed till the area of the osteotomy is "glued together" by young callus in a plastic bendable state. Quite slight manual pressure on the limb will snap the thin bridge of cortex remaining and the deformity is corrected by bending the plastic osteotomy area.

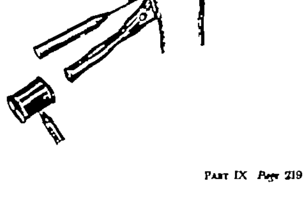
A very great advantage, clearly, is that the degree of healing at 3 weeks prevents the uncontrollable instability with overlap of the fragments, which can occasionally bedevil a one-stage osteotomy.



Completion

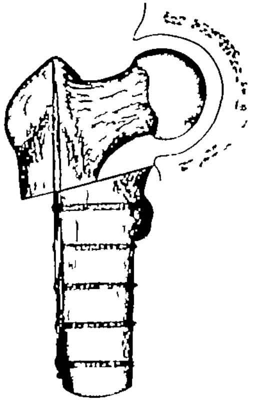
Displacement

10 In the McMurray osteotomy the upper end of the lower fragment is driven inwards under the femoral neck and head by blows on a punch (such as a Smith-Petersen impactor) applied just below the osteotomy. If this proves difficult the osteotome reinserted makes a useful slide along which the lower fragment will slide and this can be still further assisted by slight abduction of the lower fragment.

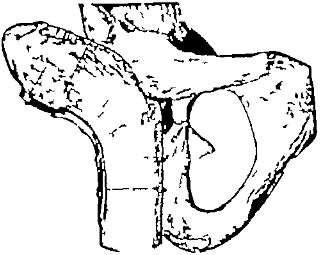


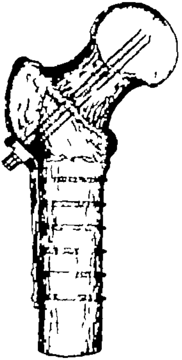
Internal fixation

11 *Displacement*—A Bosworth or Kessel spline is sometimes used. It is simply laid along the inwardly displaced femoral shaft and then driven up through the spongiosa of the trochanteric region till its tip engages in the cortex of the femoral neck. The protruding lower end is then secured to the femoral shaft in the ordinary way with screws. It prevents displacement but does not of itself provide sufficiently secure fixation and requires supplementary external splinting



12 *Subtrochanteric osteotomy*—With a transverse osteotomy for rotation or shortening, or with a cuneiform osteotomy of the Batchelor or Schanz type an ordinary bone plate, bent to an appropriate curve, as necessary is used.





13 *Cuneiform osteotomy for correcting coxa vara* — For this many forms of blade or nail and plate may be used. The McLaughlin type with adjustable angle between nail and plate is very suitable

Closure of wound

On removal of the spike retractors the vastus lateralis and tensor fasciae latae fall together and the closure of the wound in layers requires only a few interrupted catgut sutures. Drainage is seldom necessary

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Immobilization

The limb may be immobilized by means of a plaster spica or splints of the Thomas or Hodgen type with traction, the latter more for its anchoring effect than for any tractive effort. In general the spica is the better but in elderly patients traction and splintage facilitate nursing and, especially access by the physiotherapist for preserving mobility in knee, ankle and foot. The commonest mistake is to immobilize for too short a period. Each case must be judged on its merits but the need to immobilize for as long as 3–4 months is by no means exceptional in adults.

In the correction of infantile coxa vara, if no internal fixation is used, the only way of securing stable immobilization in a wriggling child is to fix the pelvis by wide abduction at both hips. It is easy to underestimate the force produced at the fulcrum of such a long lever as the leg and vascular catastrophes in the femoral capital epiphysis are by no means unknown. Internal fixation is therefore preferable.

The only common complication is the formation of a haematoma in the wound, which should be prevented or treated on standard lines.

[*The illustrations for this Chapter on Osteotomy of the Upper End of the Femur were drawn by Mr F Price*]

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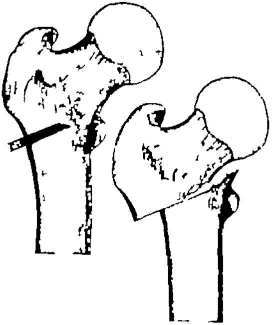
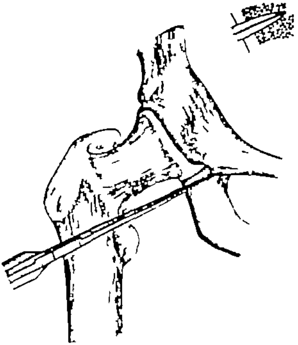


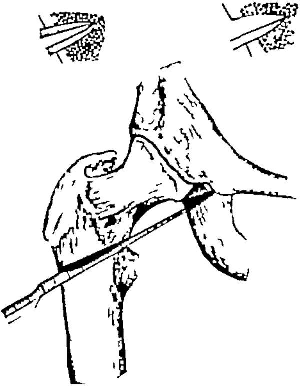
Completion of osteotomy

3 In completing the osteotomy it is important to do it cleanly and not leave a fragment of calcar projecting up from the lower fragment to interfere with the passage of the graft. For this reason some use a Gigli or reciprocating power saw to complete the cut.



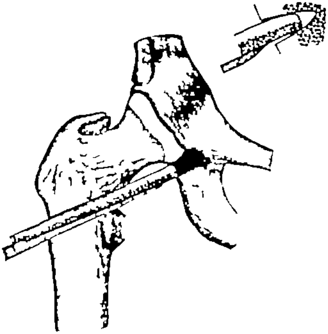
Formation of hole in ischium

4 The osteotomy completed, the osteotome, or the special Brittain paired osteotomes, is passed gently inwards and upwards in the line of the original cut for approximately $1\frac{1}{2}$ inches at which point the resistance of the ischium will be felt. A check radiograph is taken. If the aim has been good the osteotome is now driven into the ischium for half an inch or so. A second osteotome passed along the upper surface of the first and driven in with it will enlarge the hole in the ischium sufficiently to receive the end of the graft. Alternatively if the double osteotome is used, separation of its handles by the screw arrangement provided will open up the hole in the ischium in much the same manner.



Removal of single osteotome

5 Whether two osteotomes or Brittain's paired osteotomes are used, after enlarging the hole one osteotome is removed and the graft slid along the other until it impinges on the ischium.



Engagement of graft into ischium

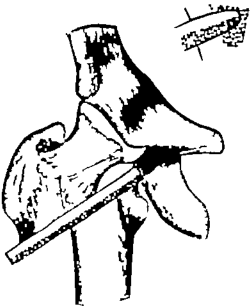
6 If the graft is passed accurately it will engage in the hole cut for it. It is then hammered home while the point of the second osteotome is just disengaged to permit this.

If this osteotome is not removed completely at this point it provides a useful skid for the next stage the displacement inwards of the upper end of the shaft fragment till it lies under the mid-length of the graft.

Displacement of femoral shaft fragment

7 This step is carried out in the same manner as the simple displacement osteotomy. The osteotome is then removed and it should be found that trochanter graft, pelvis and femoral shaft are locked solid. This invaluable stability depends upon the three point fixation of the graft—its outer end by the trochanteric portion, its middle by the displaced femoral shaft, and its inner end by its grip in the ischium.

Any undue projection of the outer end of the graft is trimmed with bone nibblers. If the osteotome is kept at all times *below* the femoral neck the risk to the sciatic nerve is extremely slight. But if the local anatomy is much distorted for any reason great care will be necessary. Wound closure presents no special features. Application of a long hip spica follows, including the opposite leg down to the knee.



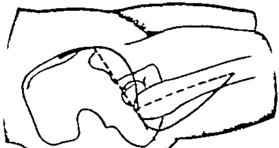
INTRA-ARTICULAR ARTHRODESIS

Approach to the Hip Joint

The approach to the hip joint is a matter of personal preference. The modified lateral approach of Charnley is here described because of its three advantages. It gives good access to the hip joint, the trochanteric region, and the anterior part of the iliac crest.

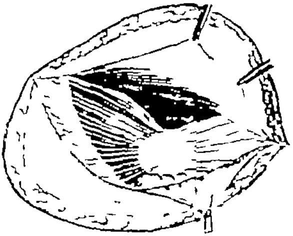
The incision

8 A double curved incision starts along the iliac crest towards the anterior superior iliac spine from a point 2 inches behind it. At the anterior superior iliac spine the incision curves backwards to reach the tip of the great trochanter. It is prolonged about 1½ inches behind the trochanter and then turns downwards and slightly forwards for 4–5 inches, converging upon the line of the femoral shaft. This avoids the pointed skin flaps of the T-shaped incision of Charnley and gives a little better access to the anterior iliac crest.



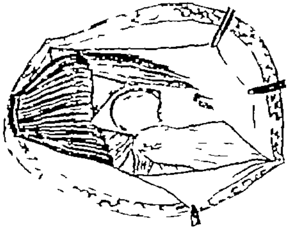
Method of exposure

9 The fascia lata exposed is incised in a T the cross-piece extending from the anterior superior iliac spine to the tip of the great trochanter and an inch or two beyond. The stem of the T runs up in the line of the femur to join the cross-piece at an angle at the tip of the great trochanter As the cross incision is deepened forwards a plane of cleavage between the anterior borders of gluteus medius and minimus and the posterior border of tensor fasciae latae is defined and followed up towards the anterior superior iliac spine. The neuro-vascular bundle running to the tensor fasciae latae will be seen and may have to be sacrificed now or later Posteriorly the incision runs across the anterior margin of gluteus maximus, which may be divided as necessary since it will have little or no function when the hip is fused. As the stem of the T is deepened the subgluteal bursa is opened and the upper part of the vastus lateralis revealed.



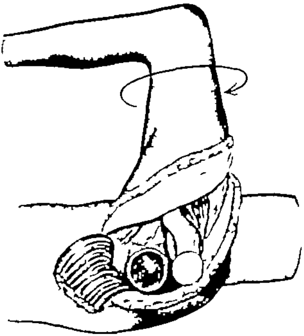
Additional exposure

10 The musculo-fascial flap on either side of the stem of the T is raised from the vastus lateralis and the insertions of gluteus medius and minimus are defined and divided as one. The two muscles are turned up by blunt dissection and stripping to expose the superior surface of the capsule of the hip joint. The capsule is next incised in the line of the femoral neck and the incision extended forwards and backwards in a T along the rim of the acetabulum.



Dislocation of femoral head

11 The hip is flexed to a right angle and the anterior margin of gluteus maximus divided to free the great trochanter External rotation of the flexed femur dislocates the femoral head. The leg, flexed to 90 degrees at the knee, should point towards the patient's opposite shoulder To attain this some tense undivided portions of the posterior and inferior part of the ligamentous capsule will have to be divided under direct vision, preferably with the diathermy knife. Finally the head and neck of the femur will be seen pointing directly at the surgeon with the acetabulum widely exposed.

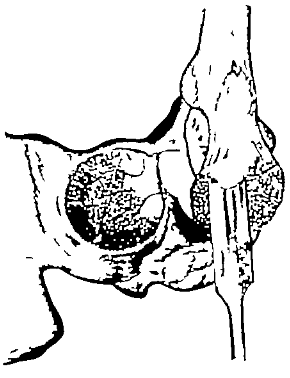


MODIFIED WATSON-JONES METHOD OF ARTHRODESIS

Exposure of both hip and trochanter by one incision and in one stage does not alter the essentials of the original two-stage operation which are (1) the erasion of the joint surfaces, (2) the packing of the joint with cancellous iliac chips, (3) the internal fixation of the joint by a long trifin nail, and (4) the addition of a superior ilio-femoral graft of iliac bone.

Erasion of articular surfaces

12 With the hip exposed the degenerated articular surfaces are "sculpted" off the femoral head by the osteotome, leaving a somewhat facetted surface, and out of the acetabulum by a long-handled gouge. The essential is to remove degenerate joint surfaces down to good healthy bleeding cancellous bone. (However it must be remembered that in the region of the cotyloid notch the bone is thin and a too assiduous pursuit of *cancellous* bone may end up within the pelvis.) The result, naturally is a diminished femoral head to be placed in an enlarged acetabulum. The space is to be filled with iliac chips.

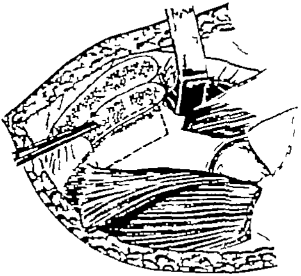


Removal of bone chips from iliac crest

13 The gluteal muscles are stripped from the outer table of the ilium, and the latter can be divided with the osteotome for 2–3 inches.

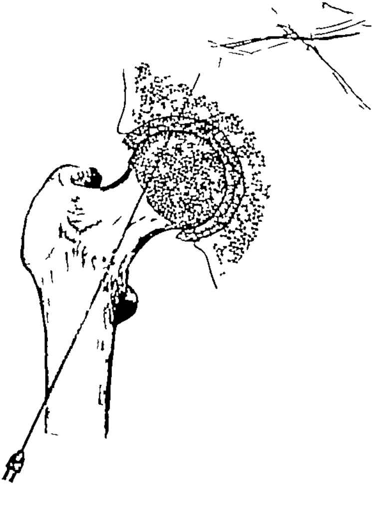
The anterior part of the crest is levered up like a lid, hinging where the inner table cracks opposite to expose the cancellous bone which is removed in chips with a small gouge. In addition, a portion of the outer table of the ilium of appropriate size (for example 2 inches by 1 inch) is removed for use later.

The acetabulum having been packed with chips, the femoral head is reduced into it and the lower limb placed in position—usually with slight flexion at the hip, neutral rotation and neutral abduction-adduction.



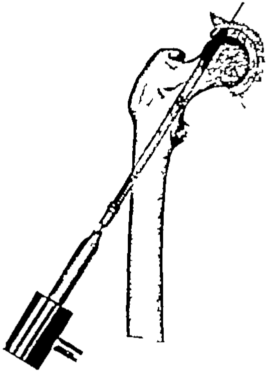
Placing of guide wire

14 The feet are secured to the foot pieces of the orthopaedic table, with the pelvis and limb held in the desired position. The subtrochanteric region is approached through the vastus lateralis as for a subtrochanteric osteotomy. Alignment of the guide wire can be judged by eye, but check radiographs, both antero-posterior and lateral, are advisable. A small hole is made, with a gouge, rather low in the cortex of the subtrochanteric region. The wire is passed through it obliquely and nearly vertically up the femoral neck into the thick roof of the acetabulum. If the nail lies in the axis of the femoral neck, it controls rotary movement at the acetabulum far less well. Moreover, the more vertical the nail the more impacting is the effect of subsequent weight bearing. Accordingly the guide wire is passed by trial and error, using a hand chuck to hold it, till a check radiograph in both antero-posterior and lateral planes shows satisfactory alignment and depth of penetration. If the first position is not satisfactory it is better to leave the wire in and pass another close beside it in correct alignment, for if it is removed, the second guide wire will have a strong tendency obstinately to follow the original track on subsequent insertions.



Insertion of nail

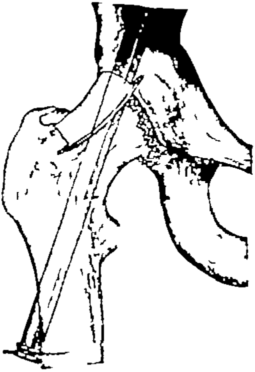
15 A suitable length of nail is deduced from the unused length of guide wire left protruding, and the nail is threaded over the guide wire and driven with a cannulated punch. It is important to measure from time to time the length of guide wire protruding after a few blows of the mallet since it is possible for the sharp "business end" of the cannulated nail to cut into the surface of a slightly bent wire and carry it with it, till its sharp point protrudes dangerously into the pelvis.



Insertion of bone graft

16 *The nail has a small hole in its head, transverse* to its long axis but just clearing the cannulated portion, through which a Pidcock pin is driven into the femoral cortex to prevent extrusion of the nail. It is necessary to orientate the point of the nail with this in mind, before it is driven.

The graft cut from the outer table of the ilium is now placed in position along the rawed surface of the femoral neck and outer surface of the ilium above the acetabular rim, bridging the joint, and it is secured either with two or more screws or by springing it into notches suitably cut in femur and ilium.



Method of closure

The gluteus medius and minimus insertions are sutured back in place. The "lid" of the iliac crest is replaced and the attachment of the abdominal muscles to it is sutured to the fascia covering the upper part of the glutei. The T-shaped cut in the fascia lata is sutured and the skin closed.

A long plaster spica, including the opposite leg down to the knee is applied.

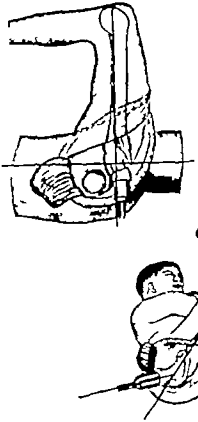
CENTRAL DISLOCATION ARTHRODESIS OF CHARNLEY

This operation has two stages, and aims at either fibrous or bony ankylosis according to circumstances, but the essential is a central dislocation of the femoral head and neck through the floor of the acetabulum, which achieves the same inward shift of the line of weight-bearing that makes the McMurray osteotomy such a reliable procedure for the relief of pain.

Cutting of femoral head and neck

Alignment

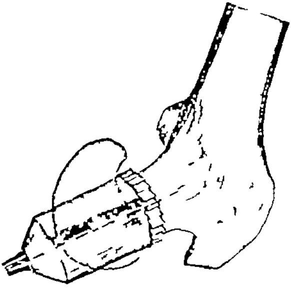
17 With the hip exposed as described the special cutter is used in a brace to shape the femoral head and neck. First, with the hip in full external rotation and the foot lying, as described, over the opposite shoulder the thigh, leg and flexed knee are in a plane facing the operator and it is necessary to align the cutter at right angles to this plane, *ignoring the anteversion of the femoral neck* If the cutter is aligned on the axis of the femoral neck it is very easy to end up with an internal rotation deformity at the hip—a severe disability Second, it is necessary to place it very carefully so that it is disposed at a varus angle of 45 degrees with the line of the shaft of the femur

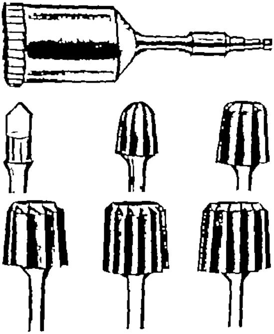


Extent of bone removal

18 Another trap lies in the distortion of the femoral head by overhanging osteophytes. It is necessary to assess the degree of overhang and place the cutter so that when all factors are considered it will *not* cut into the under-surface of the femoral neck or the calcar femorale to produce a structural weakness under weight-bearing strains.

When the cutter is thus placed the brace is rotated and the margins of the head are trephined off leaving a cylindrical raw area.





Boring of acetabulum

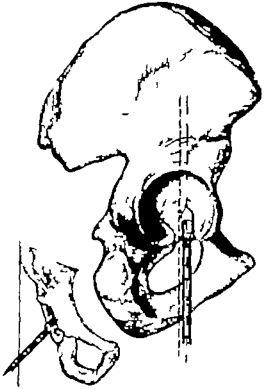
Apparatus

19 The special boring tools, held in the same brace, are passed anterior to the femur into the acetabulum

Direction of bore

20 The pointed reamer is the starter and should be placed ½ inch anterior to the centre of the floor of the acetabulum. This is so as to allow the posterior intertrochanteric ridge to ride clear in front of the posterior acetabular lip so that it does not obstruct penetration. The conical reamers are used in successive sizes and it is important to get them well into the hole in the acetabular floor so that they enlarge it. At the same time it is very easy to push them right through into the pelvis. Retrieving them can be embarrassing and far from easy However their blunt ends lift the soft tissues off the inner pelvic wall ahead of them and it would require real clumsiness to penetrate the cavity of the pelvis.

It should be remembered that to ensure a congruous fit with the cut of the femur the reamers should be in a horizontal plane and at 45 degrees to the long axis of the body provided the pelvis is flat on the operating table.

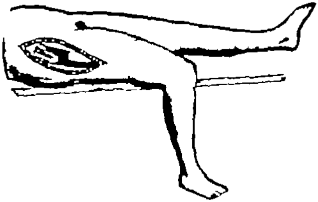


Introduction of femoral head into acetabular hole

21 The shaped head of the femur is now reduced into the reamed aperture and centrally dislocated. Ideally it should penetrate fully and the trochanter and acetabular rim should together constitute a bone block to abduction when the femur is in the neutral position It may be necessary to remove soft tissues or osteophytes from either to permit full penetration and the development of the bone block. If bony fusion is the target these opposing faces of bone should be rawed with the osteotome If fibrous ankylosis is the aim, then wound closure and the application of a plaster hip spica concludes the operation. Some of such cases will proceed to spontaneous bony fusion anyway but the majority develop sound, comfortable fibrous ankylosis.

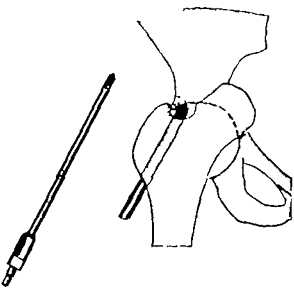
Detection of rotational deformity

22 It is very necessary to avoid an internal rotation deformity and if at the stage of reduction of the femoral head the patient is brought to the edge of the table and the leg allowed to fall into right angled flexion, any rotational deformity will be apparent, and can be corrected by re-reaming at an appropriate angle with the largest reamer



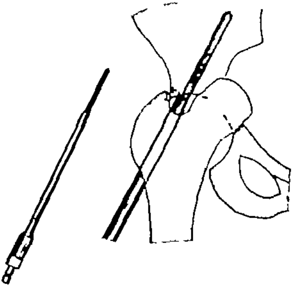
Internal fixation for bony fusion

Drilling of femur



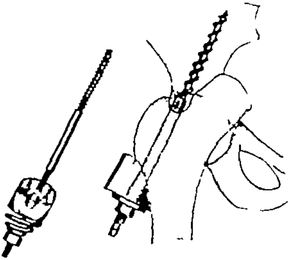
23 If bony fusion is the objective we proceed to internal fixation. The subtrochanteric region is approached on the outer aspect by "shovelling" the fibres of vastus lateralis downwards off the bone with a periosteal elevator for 2 inches. The $\frac{1}{4}$-inch drill is now started in the femoral cortex and as it grips the cortex its direction is changed till it aims at a point just internal to the superior acetabular lip. This line of aim should pass through the thickest part of the acetabular roof. A short drill is useless since the angle is acute and the drill must be brought close to the side of the thigh. The drill should emerge through the dorsum of the femoral neck, reaching *but not entering* the acetabular roof. If it does it will destroy the ultimate sound grip of the screw on cortex as well as cancellous bone.

Drilling of roof of acetabulum



24 The larger drill is extracted and the [illegible]-inch shouldered drill is now passed up the drill hole and drilled into the acetabular roof till the shoulder impinges on the bone of this roof.

Insertion of screw



25 The [illegible]-inch drill is extracted, the screw inserted in a suitable brace and passed up the drill hole to be screwed into the acetabular roof. The oblique block, the spiral spring and the nut, are threaded on the protruding end of the screw and tightened, but the nut must not be tightened too much or the screw may be stripped out of the acetabular roof. Once the spring is fully flattened tightening should cease.

Similarly in inserting the screw resistance will be felt when its unthreaded shoulder reaches the acetabular roof. Continued tightening beyond this point can only result in stripping the screw out of the cancellous bone.

Wound closure over the spring compressor presents no special problems. A hip spica is applied leaving foot and ankle free.

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

EXTRA ARTICULAR ARTHRODESIS

Complications are few. Displacement of the graft or femoral shaft is unusual if the technique has been adequate. If it occurs early it may be worth reopening the wound for replacement. A later slip leaves one with what is virtually a partly healed osteotomy and it may be wiser to accept this than to reopen the wound.

The plaster spica produces its own difficulties. It is important that the knee be immobilized in slight flexion. This helps to control rotation of the femoral shaft; moreover the elderly knee immobilized in full extension or worse, hyperextension, is very apt to develop intractable stiffness.

Phlebo-thrombosis does not seem to be a particular hazard.

INTRA ARTICULAR ARTHRODESIS

MODIFIED WATSON-JONES METHOD OF ARTHRODESIS

Attempts to shorten the period of plaster immobilization in order to lighten the burden for the elderly patient have not been a success and the tendency is towards longer rather than shorter periods of immobilization if bony fusion is to result. Four months is probably a minimum. Knee exercises can be started before the removal of the spica if the portion covering the back of the knee, calf, and sole of the foot is removed, to permit knee flexion, but kept and bandaged back in place between exercises.

CENTRAL DISLOCATION ARTHRODESIS OF CHARNLEY

Charnley himself cuts down the spica to knee length at 4 weeks to encourage knee movement, and removes it at 6 weeks, when he also removes the compressor through a small incision.

Whether the individual surgeon follows him closely in this will depend on his degree of faith in compression as an accelerator of true bony union—a conception hotly disputed in some quarters. Charnley himself admits that some cases have turned out to be cases of fibrous ankylosis after all, and contemplates the necessity of leaving the compressor in for longer. It is unlikely that he will entirely escape the experience of most surgeons in having optimism tempered by experience, and it may well be that he will gradually turn in the direction of longer immobilization in plaster. Be that as it may, the operation seems already to have justified itself as a method which produces satisfactory bony ankylosis and, perhaps just as important, where it fails to do this it produces fibrous ankyloses that seem just as satisfactory as bony ones. At the root of this lies, it seems certain, the central shift of weight-bearing that is a basic feature of the operation.

[*The illustrations for this Chapter on Arthrodesis of the Hip were drawn by Mr. F. Price.*]

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REPLACEMENT ARTHROPLASTY OF THE HIP

H. L.-C. Wood M.S., F.R.C.S.

Orthopaedic Surgeon, King's College Hospital, London; Orthopaedic Surgeon, The Royal Masonic Hospital

PRE-OPERATIVE

Indications

The operation is indicated in degenerative arthritis, when the femoral neck is too short to perform a cup arthroplasty and, especially, in cases of bilateral arthritis. In unilateral cases the operation may be an alternative procedure to arthrodesis, sub-trochanteric osteotomy or excision arthroplasty. The operation may be indicated as a method of primary treatment of subcapital fractures of the femoral neck in elderly subjects in whom union is unlikely after a nailing operation, or as a solution to the problem of avascular necrosis of the femoral head.

Special contra-indications

Replacement arthroplasty in cases of rheumatoid arthritis is unsatisfactory; involvement of the acetabulum by Paget's disease is also a contra-indication.

When the joint has been the site of previous sepsis or tuberculosis it is unwise to introduce a foreign material.

Special equipment

In addition to the appropriate prosthesis (*see* Illustration 1) special instruments required are a set of hip reamers, the largest being matched to the size of the prosthesis to be used, and a broach or rasp to enlarge the medullary cavity of the femur to fit the shaft of the prosthesis.

Pre-operative preparation

One week in hospital before operation is usually required, for blood examination and grouping. Pre-operative transfusion may be given if necessary. Instruction by a physiotherapist in breathing and hip exercises to be used post-operatively is a useful pre-operative measure.

Anaesthesia

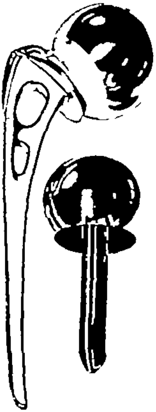
Thiopentone-gas-oxygen is the anaesthetic of choice. Diathermy prevents the use of inflammable anaesthetic substances.

A blood transfusion of 1–2 pints is set up by the anaesthetist at the start of operation.

Position of patient

The patient lies on his side as for a kidney operation with the lower limb extended, and carrying the diathermy electrode on the thigh; the upper arm is placed on a rest for transfusion. Towels must be applied so that the whole of the limb to be operated upon is free for manipulation to dislocate the hip. This is most easily done by wrapping the leg in a towel kept in place by a sleeve of stockinet.

THE OPERATION

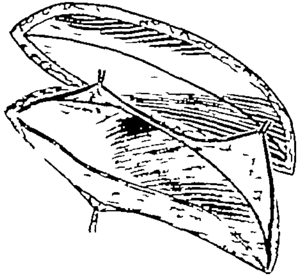


Prostheses

1 The prosthesis may be of the short (Judet) or long (Moore) type and there are many variations of pattern. The Moore type with a prolongation into the femoral shaft is much to be preferred. The prosthesis should be made of Vitallium or similar inert alloy. Stainless steel is less satisfactory and acrylic resin has proved most unreliable and should not be used. A standard size of head (53 mm.) is used and the acetabulum is made to fit. Rarely is a smaller or larger size needed.

The incision (postero-lateral approach)

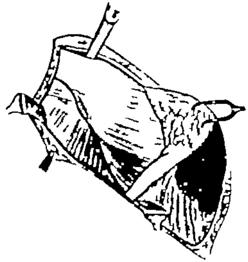
2 The incision starts 3 inches below the tip of the greater trochanter and extends upwards and curves slightly backwards to a point on the iliac crest 3 inches posterior to the anterior superior spine. This modification of the original incision gives easier access to the back of the joint (McFarland and Osborne, 1954)



Exposure

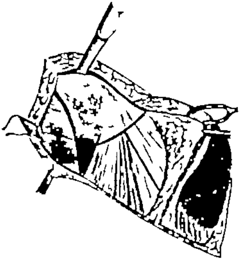
3 The ilio-tibial band is divided longitudinally starting over the trochanter and the incision is carried upwards, separating the tensor fasciae muscle in front from the gluteus maximus behind.

The gluteus medius muscle, greater trochanter and upper part of vastus lateralis muscle are now exposed.



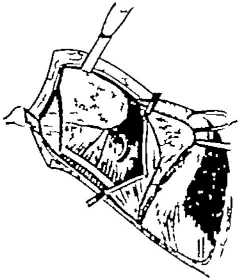
Incision of periosteum

4 The sulcus between gluteus medius and pyriformis is defined, and the periosteum incised along the posterior aspect of the great trochanter The incision is carried downwards through the upper portion of the vastus lateralis muscle.



Capsulotomy

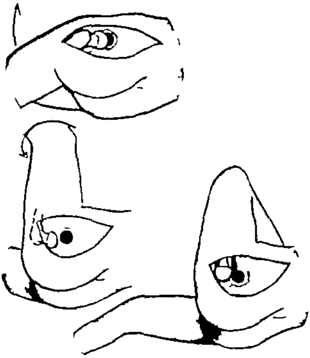
5 With the aid of a chisel, the tendon between gluteus medius and vastus lateralis is separated from the greater trochanter leaving only a thin flake of bone attached to the tendon. The gluteus medius tendon and vastus lateralis are then displaced forwards in one sheet, exposing the gluteus minimus muscle beneath. The tendon of gluteus minimus and capsule of the joint are divided in a T-shaped manner



Exposure of femoral neck

6 The femoral neck and acetabular margin are now exposed. Note the position of the sciatic nerve posterior and below the joint. It may be damaged by bone levers or retractors, or put on the stretch if the hip is dislocated forcibly

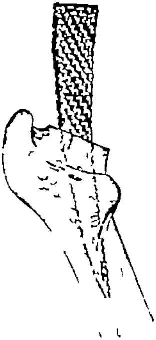
H



Dislocation of hip

7 The hip is dislocated by flexion and external rotation of the leg, which lies comfortably over the side of the operating table, supported in the lap of an assistant, who is seated.

All bleeding points are coagulated with the diathermy No ligatures are needed. The capsule and hypertrophied synovial membrane are removed as completely as possible.



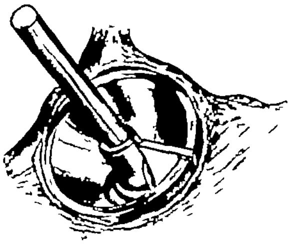
Shaping the femoral remnant

8 Removal of bone from the femur gives better access to the acetabulum and this should be done first. The femoral head and two-thirds of the neck are removed. Care must be taken to leave an inch of bone on the lower border of the neck, to form a buttress against which the Moore prosthesis will rest. (If a short prosthesis is to be used the whole of the neck is preserved and the femoral head is shaped to fit into the metallic replacement.) The medullary cavity is enlarged by driving the broach in a short way and then withdrawing it, repeatedly until the stem of the prosthesis is a drive-in fit. The prosthesis should not be finally inserted until the acetabulum has been reamered.

Shaping the acetabulum

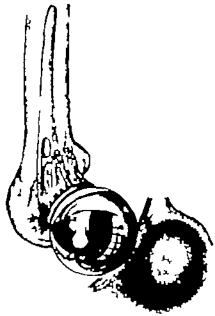
9 The cavity must be shaped so that the prosthesis is an accurate fit. Osteophytes are trimmed from the edges, and all articular cartilage and sclerotic bone are removed from the acetabulum with sharp gouges or a motor-driven burr. Graduated cutting reamers are then employed until the requisite size is reached (58 mm.) At the completion of this operation the acetabulum should be a perfect hemisphere.

Raw bone surfaces at the acetabular margin should be coagulated with diathermy to limit new bone formation. The wound is thoroughly irrigated, using a large syringe and sucker to remove bone debris.



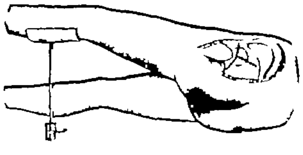
Insertion of prosthesis

10 The prosthesis is driven into the femur being hammered home by wooden punch or mallet. The hip is reduced by traction and internal rotation.



Closure of wound

11 The wound is closed in layers without drainage the leg is supported in abduction. The gluteus minimus is sutured and the gluteus medius and vastus lateralis are replaced over the trochanter by suture to periosteum or to the deep surface of the gluteus maximus. Finally the ilio-tibial band is sutured and the skin-wound is closed.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Dressing

Two layers of gauze are held in place by strips of elastic adhesive plaster applied across the wound from buttock to thigh in such a way that the buttock is lifted forward as each strip is applied over this wool is placed, held by a firm spica, to minimize haematoma formation. The spica may be removed after 4 days and the stitches after 14 days.

Adequate antibiotic cover should be given for at least a week.

Post-operative treatment

The leg must be held in internal rotation and slight abduction for 8 weeks, in order to achieve stability Skeletal traction by a Steinmann s pin inserted at the level of the tibial tuberosity enables both traction to be applied and internal rotation to be maintained by suitably arranged cords. The leg lies on a Tulloch-Brown stirrup to which is attached a traction weight of 5 pounds. The thigh is supported by a sling, the whole being counterbalanced to lift the limb clear of the bed. It is wise to arrange that the patient is lifted direct from the operating table to his bed to which should be fitted an overhead beam, pulleys, and weights in readiness. All adjustments should be made before the patient and his bed leave the theatre.

The hip may dislocate during lifting unless care is taken to maintain internal rotation.

Physiotherapy

Quadriceps and gluteal muscle drill are started on the second day together with knee movement. The patient is encouraged to sit up and lie flat for periods throughout the day

After 8 weeks, the traction and slings are removed and active exercises, such as bed skating are started.

The patient starts to walk with the aid of crutches at the end of the fifth week after operation.

Complications

The chief complications are haematoma formation and sepsis.

Superficial venous thrombosis is a common but not serious post-operative occurrence.

[The illustrations for this Chapter on Replacement Arthroplasty of the Hip were drawn by Mr F Price]

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CUP ARTHROPLASTY OF THE HIP

H. L-C Wood M.S., F.R.C.S

Orthopaedic Surgeon King's College Hospital London Orthopaedic Surgeon The Royal Masonic Hospital

PRE-OPERATIVE

Indications

Degenerative arthritis, in which there is a good length of femoral neck, is an indication for this operation. It is especially indicated in young subjects in whom arthrodesis is considered undesirable, such as bilateral congenital dislocation of the hip with arthritic changes. In the middle-aged or elderly subject suffering from degenerative arthritis, the operation is a useful method of relieving pain while preserving stability and maintaining a moderate range of movement.

The patient should be told that relief from severe pain may be expected, but that some aching or pain on weight bearing may remain. A stick will usually be required for walking but sitting or lying will be comfortable.

Special contra-indications

Operation is contra-indicated where there is a short femoral neck, avascular necrosis of the femoral head, or evidence of previous infection or tuberculosis.

In rheumatoid arthritis or ankylosing spondylitis with hip disease, cup arthroplasty seldom gives a satisfactory range of movement, and cannot be relied upon to relieve pain.

In Paget's disease, or protrusio acetabuli where the bone is soft, unsatisfactory results are to be expected.

Special equipment or apparatus

In addition to the appropriate prosthesis (*see* Illustration 1) special instruments required are acetabular reamers matched to the size of the cup and a femoral head or neck reamer according to the type of cup used. The design of instruments must be adapted to the surgical approach. When using the anterior approach of Smith-Petersen, it is difficult to shape the acetabulum by means of a straight reamer worked by a carpenter's brace. Reamers with side handles are required. The postero-lateral approach gives better access to the joint and enables straight reamers to be used.

Smith-Petersen gouges are necessary for the removal of sclerotic bone, before final shaping by the reamer

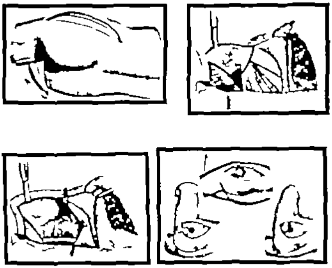
THE OPERATION

Cup prosthesis

1 Either the thin-walled mould of Smith-Petersen or the thick walled concentric cup of Crawford Adams (illustrated) may be used. The thin-walled cup or mould is to be preferred for use in young subjects in whom a good shape of femoral head can be preserved. In older subjects better post operative results are obtainable with the concentric cup and the period of post-operative treatment is much shortened.

Approach exposure

2 Cup arthroplasty can be performed through either an anterior or posterior approach. The latter is much to be preferred as giving better access to the hip joint. The technique of the posterior approach is identical with that given under Replacement Arthroplasty (see page 287) up to the point of shaping the femoral head.

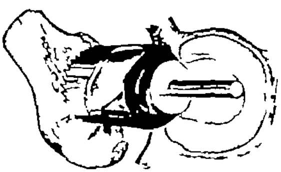


For thick-walled concentric cup

3 The special neck reamer is used. The whole length of the neck and head must be preserved, excess bone being removed from the sides of the head only

For thin-walled Smith-Petersen mould

The spherical contour of the femoral head is preserved, rough shaping being done with gouges. Final smoothing is carried out with a hollow hemispherical reamer



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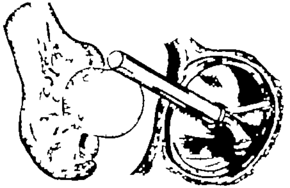
Shaping the acetabulum

The cavity must be shaped and trimmed so that the prosthesis is an accurate fit.



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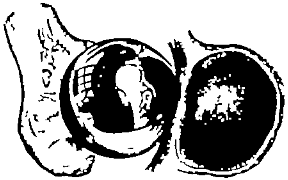
Insertion of prosthesis

The thick-walled concentric cup is a loose fit on the neck and needs only a tap with a mallet to seat it firmly

The hip is reduced and the wound is closed in layers as for Replacement Arthroplasty



POST-OPERATIVE CARE

Post-operative care is exactly as for Replacement Arthroplasty (page 241) except that when using the Smith-Petersen cup rehabilitation is slower

Post-operative traction is best applied by means of a Steinmann pin and Nissen's modification of a Tulloch-Brown stirrup

[The illustrations for this Chapter on Cup Arthroplasty of the Hip were drawn by Mr F Price]

References

Adams, J. Crawford (1953). *J Bone Jt Surg* 35B 199
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EXCISION ARTHROPLASTY OF THE HIP
GIRDLESTONE'S PSEUDARTHROSIS

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H. L.-C. Wood, M.S., F.R.C.S.

Orthopaedic Surgeon King's College Hospital London Orthopaedic Surgeon The Royal Masonic Hospital

PRE-OPERATIVE

Indications

The operation is especially indicated in cases of rheumatoid arthritis or ankylosing spondylitis with hip involvement, and in elderly patients with degenerative arthritis, for the relief of pain. A good range of movement is obtained, enabling the patient to sit at ease. A stick or crutch is necessary for walking owing to the instability and shortening which is produced at the hip joint, which may amount to an inch or more.

In hips in which a short prosthesis of the Judet type has become loose or broken, the most convenient procedure is to remove the prosthesis, trim up the neck and convert the hip to an excision arthroplasty.

Finally a septic arthritis, either primary or after some other operative procedure, may sometimes be efficiently drained by removal of the head and neck of the femur. When healing has occurred, a mobile pseudarthrosis may be obtained.

Special contra-indications

In younger patients where stability is desirable the operation should not be used.

Bilateral excision arthroplasty is sometimes permissible in the elderly but gives an ugly waddling gait.

Special equipment or apparatus

No special equipment is needed the operation can be carried out with ordinary dissecting instruments and osteotomes.

Pre-operative preparation and anaesthesia

These are as for Replacement Arthroplasty (see page 236)

Position of patient

The patient lies supine with a small firm sandbag placed under the affected hip so that the pelvis is slightly rolled to the opposite side. This sandbag not only eases access but can be used for a fulcrum about which to lever forward the head of the femur after it is dislocated from the acetabulum.

Sterile towels must be applied to the limb in such a way as to allow free mobility for the manipulations required to dislocate the joint.

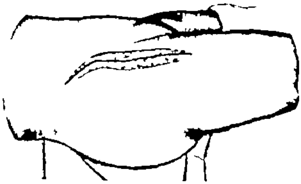
Alternative procedures

A modification of the operation is to perform an abduction osteotomy at the level of the lesser trochanter and to fix this by a special plate and screws. The intention is to give better stability to the hip joint, but this procedure is probably unnecessary.

THE OPERATION

The Incision

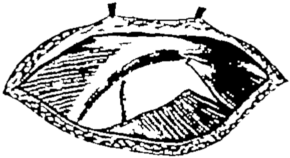
1 The skin incision is that of the anterior Smith-Petersen approach, although the deeper dissection is modified considerably from that described by him. Some surgeons prefer the short Hueter incision, but this does not give such easy access to the femoral head as does the method described. The incision starts over the anterior third of the iliac crest, extends forwards to the anterior superior spine, and is then carried into the thigh for 6 inches along the outer border of the sartorius muscle. Search should be made for the lateral cutaneous nerve of the thigh, and this should be exposed and retracted.



Method of exposure

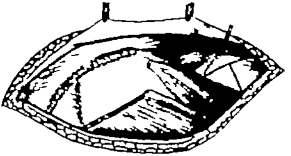
2 The deep fascia is opened along the iliac crest and the outer border of the sartorius muscle, which is retracted medially The division between this muscle and the tensor fasciae latae is defined.

It is unnecessary to ligate any vessels. All bleeding points are coagulated with diathermy Some large vessels may be encountered at the level of the lower border of the femoral neck.



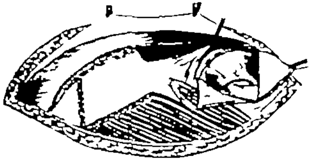
Exposure of acetabular margin

3 With a sharp osteotome the tensor muscle is stripped from the iliac bone and retracted backwards and outwards. The rectus femoris muscle is now exposed and separated from the capsule of the hip joint. The reflected head is divided, a bone lever is inserted between the rectus and pubic bone and the muscle retracted medially exposing the anterior margin of the acetabulum.



Capsulotomy

4 The capsule of the joint is opened with a T-shaped incision and the femoral head dislocated forwards by external rotation of the thigh. Difficulty in dislocation may be encountered by reason of osteophytes growing from the acetabular margin, and it may be necessary to remove these with an osteotome before dislocation is possible.



Method of dislocation

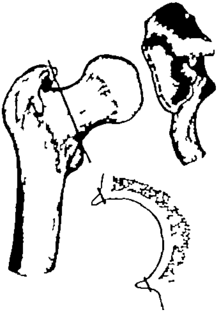
5 Dislocation is facilitated by flexing the knee to a right angle and placing the calf of the leg on the patient's opposite thigh. Gentle backward pressure in the region of the knee joint will lever the head of the femur forward over the fulcrum of the sandbag which has been placed in position.

Division of femoral head

6 The neck of the femur is defined as far laterally as the intertrochanteric line. With a sharp osteotome the whole head and neck are removed slightly above this level, care being taken that the bone does not split at its posterior aspect. All osteophytes are carefully removed from the margin of the acetabulum: this is important: projecting bone spicules may be the source of subsequent pain. Raw bone surfaces are coagulated by diathermy to reduce the bleeding and limit new bone formation.

Closure

After careful toilet to remove all loose bone fragments, and complete haemostasis having been secured with diathermy, the tensor muscle and deep fascia are sutured back to the iliac crest and margin of sartorius, without drainage.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

The dressing is held in place by strips of elastic adhesive dressing applied across the wound. They sh applied to the buttock first before attachment to the abdomen and thigh, in order to minimize haematoma tion. A firm pressure dressing of wool and a hip spica are then applied.

Traction must be maintained on the leg for 6 weeks. Skin or skeletal traction may be used, preferably th by a Steinmann pin inserted at the level of the tibial tuberosity A 10-pound weight is attached to the pin by of a stirrup and the limb is supported on slings which are counterbalanced to sling it clear of the bed. The li tend to roll outwards and this tendency must be corrected by means of a cord attached to the outer end Steinmann pin.

Complication

Damage to the lateral cutaneous nerve of the thigh, with its consequent area of anaesthesia or hyperaest sometimes a nuisance to the patient.

Physiotherapy

Quadriceps contractions and knee movements may be started on the second day The stitches are removed fourteenth day and provided the wound is soundly healed, active hip movements are commenced.

A weight-bearing caliper must be worn for at least 6 months.

[The illustrations for this Chapter on Excision Arthroplasty of the Hip were drawn by Mr F Price]

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NAIL FIXATION FOR FRACTURE OF THE NECK OF THE FEMUR

G L W BONNEY M.S., F.R.C.S.

Consultant Orthopaedic Surgeon to St Mary's Hospital and Paddington Green Hospital London Consultant Orthopaedic Surgeon to The Florence Nightingale Hospital and The Royal Masonic Institution for Girls Research Assistant to the Institute of Orthopaedics London

PRE-OPERATIVE

Indications

Recent fracture of the femoral neck with displacement, in adults. Some impacted or incomplete fractures of the femoral neck it is certain that most of these unite when treated conservatively nailing offers the possibility of earlier ambulation and avoids the occasional occurrence of disimpaction during the course of conservative treatment.

Special contra-indications

In about one-third of all cases of displaced fractures of the femoral neck, avascular necrosis of the head of the femur is likely to occur In these patients the useful service performed by the pin is limited to that of enabling them to be moved and nursed easily during the first weeks or months after operation. It will not secure a functional result. Hence in cases where extreme old age, severity of the fracture or placing of the fracture immediately below the femoral head, indicate the likelihood of avascular necrosis, replacement of the femoral head may be preferable to nailing of the fracture. It is not, however possible to be certain from clinical and radiological evidence which fractures are likely to be complicated by avascular necrosis, so that in this respect no hard and fast rule can be laid down.

Fractures of the femoral neck in young children are usually best treated by manipulative reduction and plaster immobilization.

Pre-operative preparation

Most patients are old and special attention must be given to their general condition. In general, it is wise to fix the fracture as soon as possible after the injury since after the initial shock has passed off the patient's condition does not markedly improve with rest in bed while the fracture remains mobile. Should a delay of two or three days be inevitable some relief of pain can be afforded and—possibly—further damage to the vessels supplying the femoral head can be prevented, by a simple extension with skin traction.

Anaesthesia

General anaesthesia is preferred, but should this be contra-indicated by pulmonary complications or by greatly impaired renal function, local anaesthesia may be used.

Special apparatus and instruments

The operating table.—It is most convenient to use an "orthopaedic" operating table The principal features of such a table are as follows the patient's head and the upper part of his trunk are supported on the main part of the table and his sacrum lies on a "pelvic rest" The distance between these two parts of the table may be adjusted according to the height of the patient. Each foot is separately supported on a foot-piece which is mounted on a bar so hinged as to allow for movement of the hip in the horizontal plane. The foot-pieces are also to a limited extent adjustable in the vertical plane All parts where weight is taken should be well padded.

Instruments

Guide wires.—Nine-inch stainless steel guide wires 3 mm. in diameter, barred alternately in polished and satin finish, are the most satisfactory. At least two are needed, and care should be taken to ensure that they are of equal length.

Starter.—The cannulated starter has a trifin end so that with it marks can be made in the cortex of the femur which will determine the rotational position of the nail.

Nails.—Two types of cannulated trifin nail are in general use—the Sven Johansson type and the modified nail introduced by Watson-Jones. In the latter (illustrated here) the head is modified so as to allow for the introduction of a cross-pin.

Punch.—The cannulated punch is expanded at one end to accommodate the nail, which is held in the punch during the early stages of introduction. The other end is shaped so as to fit on to the slightly convex surface of the head of the nail.

Impactor punch.—The impactor punch is shaped at one end so as to fit on to the convex outer surface of the femur and this end is set at an angle to the shaft of the punch so that it lies parallel with the shaft of the femur when the impactor is held in line with the nail. The end of the impactor punch has a central hole which accommodates the head of the nail so that the force is applied to the bone and not to the nail.

The extractor.—This instrument is designed on the principle of a double-action corkscrew. The jaws are tightened on the head of the nail, which is then removed by screw traction, the counter-force being applied to the bone.

The ruler.—A stainless steel ruler marked in inches and in centimetres is essential for calculating the length of the nail required.

Position of patient

A special table is commonly used, but many surgeons now use an ordinary operating table, a flat box to take the x-ray plates being placed under the patient's pelvis.

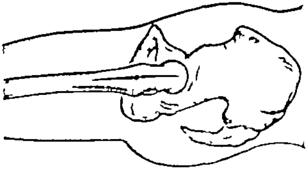
Reduction of the fracture

After anaesthetization the patient is placed on the table and the foot on the sound side is bandaged to its foot-piece. While an assistant grips the patient's pelvis, the fracture is reduced by steady traction on and internal rotation of the leg on the affected side. Rotation is continued until the neutral position is reached, and at the same time the hip is abducted to about 20 degrees. The foot on this side is now bandaged to the foot piece.

When an ordinary operating table is used, reduction is carried out in the manner described, and the position is maintained by allowing the knees to bend so that the patient's legs hang down over the side of the table. The feet are supported on stools placed on each side of the table.

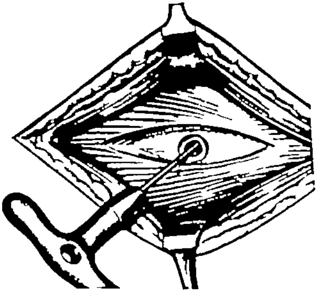
Now the portable x-ray apparatus is positioned. One tube (for the antero-posterior view) is placed vertically above the hip, the other (for the lateral view) is placed on the inner side of the knee of the healthy side, so adjusted that its beam will be directed obliquely through the line of the hip joint. The plate for the antero-posterior view is conveniently held in a cassette box or in a slot placed in relation to the pelvic rest. The plate for the lateral view may either be held in a specially constructed plate holder, or may be held by the surgeon, pressed into the patient's side *above the iliac crest at such an angle as to be at right angles to the x-ray beam.* When these arrangements have been made, radiographs in antero-posterior and lateral projections are taken. If these confirm accuracy of reduction, nailing can be proceeded with; if reduction is inadequate, further manipulation must be undertaken until a perfect reposition is obtained. The towels are now placed in position, and the area of operation is covered by stockinet secured by Mastisol.

THE OPERATION



The incision

1 A 4-inch incision is made in the line of the femoral shaft, centred on the lower margin of the greater trochanter



Exposure

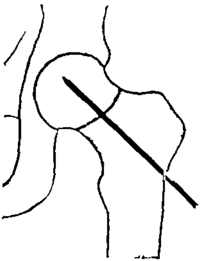
2 The tensor fasciae latae—muscular in the upper and tendinous in the lower part of the incision—is divided in the line of its fibres. Some fatty tissue usually underlies the tensor and division of this exposes the tendinous upper origin of the vastus lateralis. The latter muscle is now divided in the direction of its fibres for about 3 inches downwards from the tendinous origin to expose the outer side of the femoral shaft.

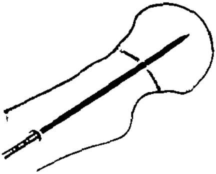
At a point on the outer side of the femoral shaft about $1\frac{1}{4}$ inches below the tendinous origin a disc of cortex about $\frac{1}{4}$ inch in diameter is removed with a small gouge.

Insertion of guide wire

3

Through the hole in the cortex a 9-inch guide wire is introduced. The direction in which it should be inserted can, with some accuracy be deduced from the post-reduction radiographs. If the direction is correct, the guide wire will be felt to enter rather easily for the first $2\frac{1}{2}$ inches, after which—as the point enters the bone of the femoral head—the resistance increases until the considerable resistance of the cortex of the head is encountered. At this point the depth of insertion will be about 8–$8\frac{1}{2}$ inches. Further radiographs in the antero-posterior and lateral projections are now taken. If these show that the guide wire is in a good position, then it is possible to proceed to the insertion of the nail if not, a second guide wire must be introduced, the new direction being deduced from the position of the first. Accuracy in placing the guide wire is very important, since the greatest grip on the bone will only be secured by a nail running up the femoral neck into the centre of the femoral head. It is advisable to place the nail rather below the central axis of the neck and to have its direction rather more vertical than that of the central axis. By this means the nail is made to engage the more condensed bone of the inferior part of the neck and to engage the head firmly



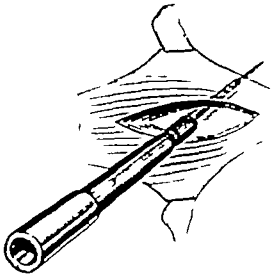


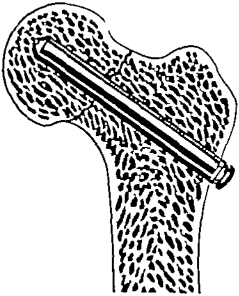
Insertion of the nail

Use of "starter"

4

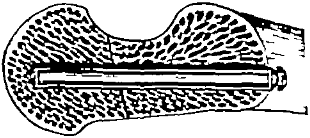
The guide wire having been correctly placed, the cortex of the shaft is prepared for the reception of the nail by means of the "starter" which is threaded over the guide wire and punched in to mark the bone. It is important to make these marks in the correct position of rotation if it is desired to insert a cross pin to hold the nail. The length of the nail required is now calculated by measuring the length of guide wire protruding from the femur and subtracting this length from that of the guide wire

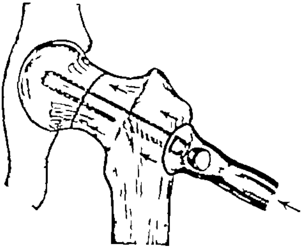




Driving in of the nail

5 The nail chosen is threaded over the wire and driven in by blows of the hammer on the cannulated punch Every second or third stroke the length of guide wire protruding should be carefully measured to ensure that it is not being driven in with the nail. When the nail has been driven in so that its head lies flush with the cortex the guide wire is removed.



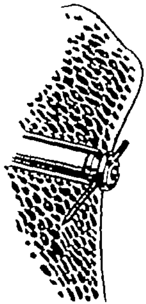


Impaction of the fracture

6 The fracture is now impacted with a few blows on the impactor punch.

Insertion of the cross pin

7 The cross pin may now be inserted through the hole in the nail head. It is usually necessary to make a hole in the cortex for its reception, a $\frac{1}{16}$ inch drill being used for this purpose. Final radiographs in both projections are taken to make sure that the nail has been correctly placed and that it is of the right length.



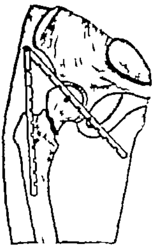
Closure

The vastus lateralis and the tensor fasciae latae are sutured, and the skin closed. A simple dressing secured by adhesive plaster is usually satisfactory

Other methods of insertion of guide wire

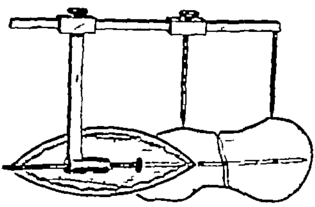
Hey Groves director

8 Some surgeons prefer to rely on special instruments, rather than on the sense of touch and of direction deduced from radiographs, for the introduction of the guide wire. Perhaps the best known of these special instruments is the Hey Groves director in which the direction in the horizontal plane is calculated from a notched protractor laid in the skin, and the direction in the vertical plane from a guide wire holder with two spikes, one of which is driven through the skin into the femoral head, the other being driven into the neck in the region of the trochanteric line. The danger of perforating the femoral artery with the inner spike of this instrument has been somewhat overstressed—in most cases the pulsation of the vessel can be felt and the spike inserted lateral to this point.



Brittain's method

Of other methods, that of Brittain (by Michel clips on the skin for the antero-posterior direction and a guide wire along the surface of the neck for direction on the vertical plane) is probably the most widely used.



POST-OPERATIVE CARE AND COMPLICATIONS

Movements of the hip and knee are encouraged from the start, and the patient should be sat out of bed from the first post-operative day Some surgeons protect the fracture fixation by fitting a shoe with a bar nailed to the heel to prevent lateral rotation, but if the nail has been correctly placed this step is not necessary If on the other hand the nail has been incorrectly placed, no such device will prevent its cutting out. As to the time when walking and weight-bearing are permissible, opinion is much divided, some encouraging early weight-bearing and others preferring to defer it for three or more months. It is likely that the prognosis of any disimpacted fracture of the femoral neck is determined at the time of injury so that in theory its course would be little influenced whether weight-bearing were deferred or not.

Special complications

The most serious operative complication is breaking of the guide wire during insertion of the nail. Under such circumstances the pointed end of the guide wire may be driven on by the entering nail to penetrate the hip or—more serious—the pelvis and one of the pelvic viscera. If the broken end of the guide wire is in the hip joint, removal is desirable, and can usually best be accomplished by pushing the broken piece through the floor of the acetabulum with a second guide wire, and removing it from within the pelvis by an extra-peritoneal approach. In the case of penetration of the pelvis, removal is absolutely necessary

The early post-operative complication of extrusion or cutting-out of the nail is usually due either to faulty placing of the nail or to sepsis. The complications of later extrusion of the nail and of collapse of the femoral head are usually due to avascular necrosis of the femoral head, and may occur however skilfully the nail has been introduced.

If for any reason—unfavourable type of fracture or delay in the institution of treatment—a good functional result is unlikely to be secured by nailing, replacement of the femoral head is preferable to nailing The hip is exposed through an anterior or lateral approach and the head is replaced by a prosthesis. Many varieties of prosthesis are available but the metal type with a long stem fitting into the medullary canal of the femur is the most satisfactory The Moore prosthesis is an example of this type

In general, the older the patient and the worse the general condition, the more urgent is the indication for the fixation of the fracture. There are, however some cases where even the simplest form of intervention cannot be contemplated and in these it is best to disregard the fracture and to concentrate on keeping the patient mobile so as to avoid the dangers of bed-sores and broncho-pneumonia.

In cases where the fracture has been neglected for so long that the neck of the femur has been absorbed, the most useful procedure for the relief of pain is that of Girdlestone. In this, a pseudarthrosis is formed by the removal of the head and any remaining part of the neck of the femur the removal of the upper margin of the acetabulum and the insertion of the short rotator muscles between the femur and the acetabulum (*see* page 248)

[*The illustrations for this Chapter on Nail Fixation for Fracture of the Neck of the Femur were drawn by Mr R. N Lane*]

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NAIL-PLATE FIXATION OF TRANS-TROCHANTERIC FRACTURES

NORMAN CAPENER, F.R.C.S.

Consultant Orthopaedic Surgeon Princess Elizabeth Orthopaedic Hospital and Royal Devon and Exeter Hospital Exeter Mount Gold Orthopaedic Hospital Plymouth

PRE-OPERATIVE

Indications

There are two main reasons why for most transtrochanteric fractures, it is advisable to apply some form internal fixation. The first is that many of them are unstable when reduced and the intrinsic forces of muscu activity are prone to cause redisplacement and disabling deformity when union has occurred. The other reasor that, because so many of such fractures occur in elderly people, it is possible when they are so fixed to mobil the patient in bed and at an early date permit him to sit out of bed. For the last reason the operative treatmen not only life saving but it does also make the problem of nursing very much easier

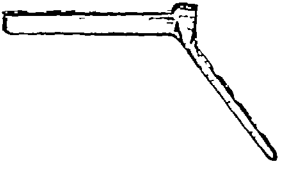
Position of patient

It is advantageous to place the patient upon an orthopaedic operation table so that traction with some abducti upon the limb may be maintained throughout. It is possible to carry out the procedure without such a table two extra assistants are available one to hold and pull upon the affected limb, the other to exert counter tracti through a sling passed around the pelvis, the adductor region and beneath the ischial tuberosity The pati usually lies upon his back, the sacral area being suitably padded. If the patient's general constitutional state satisfactory a better method is for him to lie on his face. Where displacement is not a marked feature it is possil to perform the operation without radiographic control, though this is preferable where it is readily available.

APPARATUS

1 There are many devices available. Neufeld and Blount in the United States developed angulated plates, one portion of which had a V-section which entered the femoral neck and the other portion was flatter for application with screws to the outer side of the femoral neck.

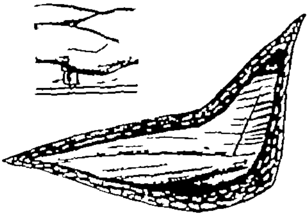
In Great Britain the Capener nail-plate is similar in principle Two-piece appliances comprising on the one hand what is essentially a Smith-Petersen trifin nail, which gains a hold upon the femoral neck, is secured by bolts or other devices to a plate upon the outer side of the femoral shaft. The easier application of these two-piece instruments is counterbalanced by the greater mechanical weakness at the angle of junction.



THE OPERATION

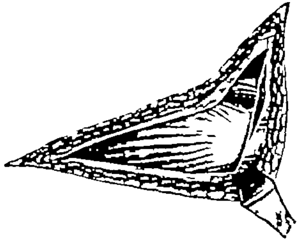
The incision

2 A line is taken from the posterior margin of the great trochanter downwards for at least 6 inches. If the operation is being done under radiographic control this should be sufficient A more complete visualization of the procedure is gained by extending the incision from the top of the vertical incision forwards and upwards along the line of the femoral neck for 3–4 inches.



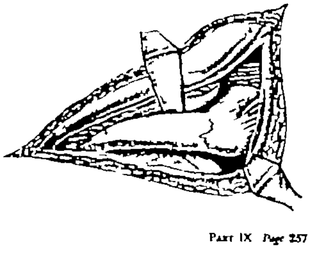
Superficial dissection

3 The vertical portion of the incision is deepened to the fascia femoris which is incised in the same line and its two edges retracted to expose the vastus lateralis, the surface of which is followed backwards to its attachment to the femoral shaft posteriorly and around the lateral aspect of the great trochanter from both of which it is detached and then the whole muscle thus exposed is retracted forwards by subperiosteal stripping from the lateral face of the femoral shaft. One or two perforating vessels may be cut in the process and these should be picked up with haemostats and cauterized.



The anterior extension of the approach

4 In the forward and upward extension of the incision the tensor fasciæ femoris muscle will be divided transversely and at its anterior border care must be taken to avoid damage to the lateral femoral cutaneous nerve. The advantage of the extension is that the reduction may be checked visually and that the upper and lower boundaries of the femoral neck may be defined for the guidance of the nail-plate introduction

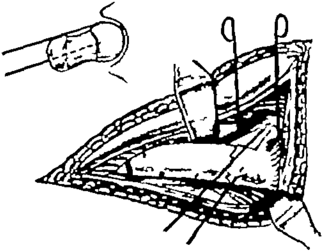


Estimation of alignment of V-nail fixation device

5 A guide wire may first be directed along the surface of the neck of the femur and its point embedded in the femoral head. If this is done posteriorly the guide wire should pass through the posterior intertrochanteric ridge in order to be close to the posterior surface of the femoral neck.

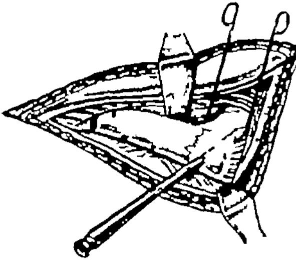
The precise line of the centre of the femoral neck may be found by passing blunt dissectors or narrow bone elevators one above and the other below the femoral neck and having them project vertically from the wound.

A second guide wire is now passed up the centre of the femoral neck parallel to the first guide wire in the antero-posterior plane. Control radiographs are now taken and the angle of the nail-plate to be used is determined together with the length of the V-nail portion which should extend approximately to the centre of the femoral head. Should the direction of the guide wires not be satisfactory the position of both should be altered. The most commonly used nail-plate is one having an angle of 180 degrees—the nail and plate sections being both 8 inches in length.



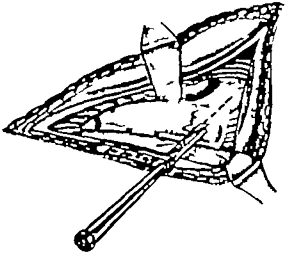
Insertion of V-nail

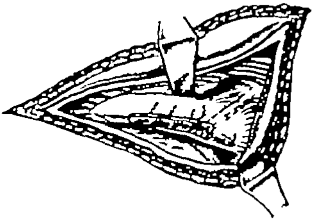
6 For the insertion of the nail-plate a starting instrument is used to cut a V of the correct shape through the lateral femoral cortex, the apex of the V cutting instrument lying immediately inferior to the point of penetration of the second guide wire and its handle lying in the same coronal plane as the femoral shaft with the V pointing downwards directly along the shaft.



Control of direction

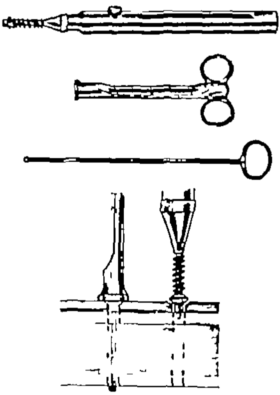
7 The correct nail-plate is then inserted and while hammering the device into position through its introducing handle the surgeon must keep constant watch to maintain direction, not only of the V-nail section as it enters the femoral neck but also the lateral plate particularly ensuring that the latter is maintained absolutely parallel to the femoral shaft in the coronal plane during the whole process.





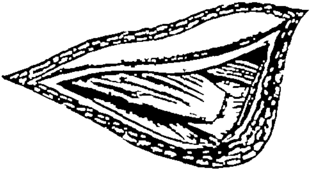
Fixation of nail-plate

8 When the plate has been approximated to the lateral surface of the femoral shaft, the centre of each screw hole in the plate is marked by the use of a self-centring punch having a shaped end-piece to fit accurately the screw hole. Into the minute central depression thus made a drill point of suitable size is applied and directed at right angles through both the lateral and medial cortices. The length of screw to be used is determined with a gauge and the appropriate screw is inserted through the plate and across the femoral shaft. This process is repeated for all the screws and then a final adjustment of firmness of each is made without tightness being forced.



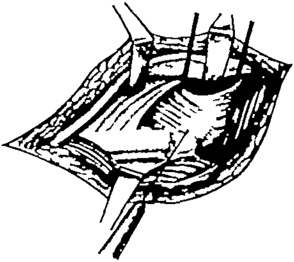
Closure of wound

9 When final radiographs have shown a satisfactory reduction and fixation the wound is closed by inserting a few fine linen sutures approximating the vastus lateralis to the lateral intermuscle septum close to the femoral shaft. The fascia femoris is similarly sutured and the skin wound closed.



The posterior extension

10 The posterior extension of the approach which may be used when the patient is on his face follows the line of the Kocher incision between the lateral fibres of the gluteus maximus and the tensor fascia femoris. In this variation the fracture line is most readily seen and the line of the femoral neck is determined.



POST-OPERATIVE CARE

The patient is nursed on his back with an air ring under the sacrum and two pillows placed transversely under the knees, thus maintaining some flexion for the hip and knee joints. The heel should be protected with a heel-ring A sand-bag may be placed on the mattress at the inner side of the foot so as to prevent eversion of the hip Within a few days graduated supported movements of the hip and knee are commenced. The opposite limb and the arms are freely exercised and changes of posture into the semi-sitting position and breathing exercises are encouraged from the beginning The patient should be encouraged to lift himself freely by the provision of an overhead suspension rope and handle and he may be rolled over from one side to another daily providing the affected limb is maintained carefully in the neutral position Sitting in a chair is encouraged at 4 weeks and ambulation with the help of crutches at 6 weeks.

[The illustrations for this Chapter on Nail-Plate Fixation of Transtrochanteric Fractures were drawn by Mr J Wheldon from originals by Mr Norman Capener]

EXCISION OF A SEMILUNAR CARTILAGE OF THE KNEE

M. S Brett F.R.C.S.

Senior Registrar The Royal National Orthopaedic Hospital, London

PRE-OPERATIVE

Indications

The abnormalities of the semilunar cartilages which justify their removal are tears, cystic lesions and congenital discoid formation.

Torn cartilage

If the diagnosis of a torn cartilage is only suspected it is always advisable to concentrate on conservative treatment by exercises to try and restore normal strength and tone to the quadriceps muscle. But if the diagnosis of a "bucket-handle" tear of the cartilage can be made confidently after the first episode of symptoms it is best to remove the cartilage as soon as possible.

When a torn cartilage leads to repeated attacks of pain, locking and swelling of the knee, it should be removed.

Cysts

There is no indication for removal of a cystic cartilage unless it is causing pain or is interfering with normal joint function, in which case operative treatment is advisable.

Congenital discoid formation

A congenital discoid cartilage which causes sufficient disability by upsetting normal joint movement may have to be removed.

Contra-indications

In the presence of well-established degenerative changes in the knee joint, the removal of a torn cartilage should not be undertaken unless the symptoms are attributable to the cartilage lesion only The post-operative course is apt to be prolonged by pain, muscle-wasting and recurrent effusions.

Pre-operative preparation

It is a good plan to instruct the patient in active quadriceps contractions before the operation so that it will be easier for him to overcome the post-operative inhibition of the muscle as soon as possible afterwards.

Position

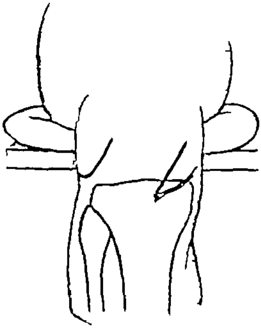
The patient lies supine with both knees flexed over the end of the operating table The lower thigh of the affected side rests on a sandbag The leg is exsanguinated with an Esmarch bandage and either a pneumatic tourniquet or a second Esmarch bandage is placed round the upper thigh. It is a wise precaution for the tourniquet to be tied to the operating table so that the patient cannot be transferred to a trolley after the operation without its removal The surgeon sits with the foot of the affected leg resting on his knees so that he may control the position of the knee in front of him.

THE OPERATION

REMOVAL OF MEDIAL SEMILUNAR CARTILAGE

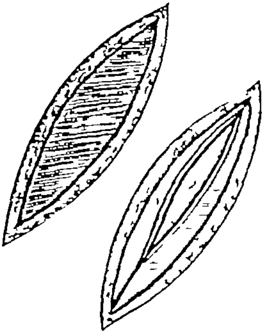
The incision

1 The incision is placed over the antero-medial compartment of the knee and passes obliquely downwards towards the insertion of the patellar tendon. It is important that it should not extend more than ¼ inch below the head of the tibia, because of the risk of damaging the infrapatellar branch of the long saphenous nerve. Some surgeons prefer to make the incision downwards and medially because less retraction is necessary to expose the peripheral attachment of the cartilage.



Deep incisions

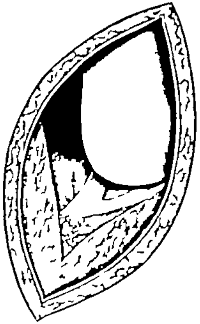
2 The subcutaneous fat, deep fascia and capsule of the knee joint are incised in the same line. The capsule is more easily defined at the end of the operation if it is undercut slightly on each side. A variable amount of extrasynovial fat is next encountered before reaching the synovial membrane, through which the joint is entered. The incision through this layer is started where it is thin over the femoral condyle at the upper end of the wound. If there is a synovial effusion the entry into the joint cavity is made easier because the synovial membrane is bulging forwards.

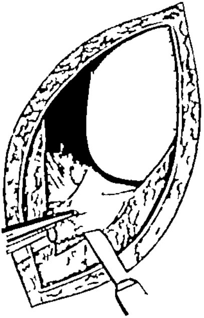


Exposure of cartilage

3 The fatty tissue and synovial membrane are retracted medially to display the anterior end of the medial cartilage. If a bucket-handle tear is present it will be clearly visible. Whatever the state of the medial cartilage it is wise to look for abnormalities of the other accessible structures in the joint first: the cruciate ligaments, the articular surface of the femoral condyles and patella, and the lateral cartilage must all be inspected as far as is possible.

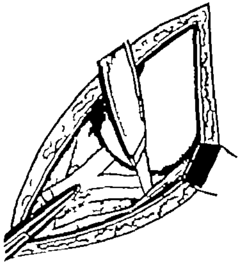
If the clinical diagnosis of a torn cartilage is reasonably certain and no abnormality can be seen in the anterior part of the cartilage or the rest of the joint, the surgeon should proceed to remove the medial cartilage. A posterior tear cannot be detected until the anterior horn is freed or until after the whole cartilage has been removed.





Freeing of anterior horn

4 The anterior horn is first freed by a vertical incision extending down on to the head of the tibia and a horizontal incision to sever its coronary attachment.

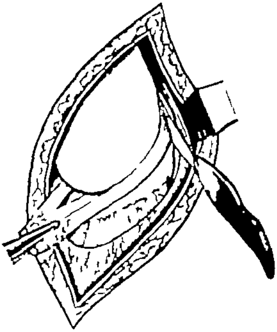


Severance of peripheral attachment

5 The anterior horn is now grasped firmly with toothed Kocher's forceps. A Langenbeck retractor is inserted on the medial side and the line of attachment between synovial membrane and the cartilage is identified. The grey-pink colour of the synovial tissue contrasts with the yellow tinge of the cartilage. By incising vertically along this dividing line, the cartilage is severed from its peripheral attachment to the synovial membrane.

"Blind" mobilization

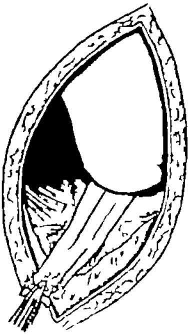
6 The cartilage is freed under direct vision back to the medial ligament of the knee. Further mobilization beyond this point has to be done blindly. The aim is to bring the whole cartilage into the centre of the joint by dividing its peripheral attachment, leaving only the posterior horn to be severed. This is achieved by pulling the cartilage forwards and laterally while making small vertical strokes with the tip of the scalpel along its marginal attachment. The confined space and lack of clear vision at this stage make it essential to wriggle the scalpel forward very slowly, keeping it strictly vertical. In this way any risk of cutting the medial ligament is avoided. When there has been a traumatic peripheral detachment of the posterior half of the cartilage, it can be displaced into the centre of the joint immediately the attachment to the medial ligament has been severed. But in the case of the more common longitudinal tear, the attached rim of cartilage may be rather thin and it is possible to tear it across by too vigorous traction. It is important to make sure of the complete removal of the posterior half of the cartilage whether torn or not, otherwise symptoms may persist after the operation.



Severance of posterior attachment

7

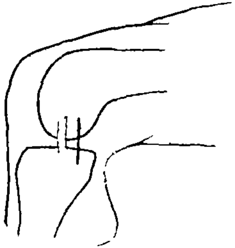
When the cartilage has been displaced into the centre of the joint the posterior attachment is severed. The cartilage is pulled forward strongly and its complete removal is accomplished with the scalpel by incising down towards the head of the tibia, thus avoiding the risk of damaging the posterior capsule of the knee. Finally the peripheral attachment of the cartilage is inspected again so that any loose tags can be removed.



Removal of posterior remnant of cartilage

8

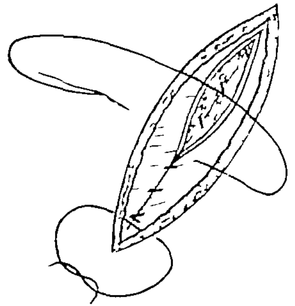
In the event of the posterior end of the cartilage being left behind it is necessary to make a separate vertical incision posterior to the medial ligament of the knee. This leads straight down to the joint line, and the remaining piece of the cartilage can be removed easily.



Closure

9 The synovial layer is closed with a continuous haemostatic suture of fine catgut. The edges of the capsule are brought together more easily if the knee is held extended. The skin is closed with interrupted sutures

Note —An alternative technique for removing the cartilage with special end-cutting knives is recommended by Smillie (1946) and used by many surgeons.



REMOVAL OF LATERAL SEMILUNAR CARTILAGE

The techniques of this operation and that of excising a cystic lateral cartilage (*below*) are so similar that they are not separately illustrated.

The incision is placed over the antero-lateral compartment of the knee and runs downwards and backwards from the border of the patella. The joint is opened in the line of the incision as on the medial side.

The dissection of the anterior half of the lateral cartilage is performed in exactly the same way as on the medial side Fortunately it is possible to pull it forwards more easily than the medial cartilage because it is not attached to the lateral ligament. The tendon of popliteus is exposed posteriorly where it lies between the cartilage and the capsule

CYST OF LATERAL CARTILAGE

If the cystic swelling is small there is no modification of the technique but if it is large the skin incision may be extended posteriorly This will allow a skin flap to be turned back.

The anterior end of the cartilage is dissected back as far as possible in the usual way

The cyst lies outside the synovial membrane but deep to the capsule. Therefore a second incision is made through the capsule directly over the swelling The cyst can then be dissected under direct vision outside the joint. It may be removed separately from the cartilage or together with it, whichever is easier Care must be taken to recognize the inferior lateral geniculate artery which lies deep to the lateral ligament, so that if it is cut during the dissection of the cyst it may be ligated.

POST-OPERATIVE CARE AND COMPLICATIONS

After operation the straight, but not hyperextended, knee is immobilized in a plaster cylinder applied over several layers of wool. Regular exercises for the quadriceps muscle are started the following day. They include contractions of the muscle and lifting the straight leg from the bed.

After 10 days the sutures are removed and the plaster cylinder is replaced by a firm crepe bandage.

Regular non-weightbearing exercises are continued until the quadriceps muscle has regained its tone and is strong enough to maintain full extension of the knee against gravity. After this has been achieved, the patient is allowed up. The return of full flexion is not usually a problem but the maintenance of a full range of active extension is essential for the stability of the knee when walking. If the patient walks before this, the synovial effusion increases, the tone of the quadriceps is lost, and recovery is delayed. Regular exercises must be continued for several weeks until the power of the quadriceps is normal, as measured by weight lifting.

Complications

Persistent effusion

This is usually associated with early walking before the quadriceps muscle has become strong enough to hold the knee stable. It is more likely to occur when there are degenerative changes in the knee joint. Treatment consists of intensive quadriceps exercises in bed and a firm pressure bandage. Occasionally aspiration of the joint is necessary.

Haemarthrosis

A small amount of bleeding into the joint after the removal of a semilunar cartilage is inevitable but occasionally a large haemarthrosis occurs. This is particularly liable to follow the removal of a lateral cartilage, when the lateral geniculate artery may be damaged. Within 48 hours of the operation the patient complains of severe pain in the knee and the temperature may be raised to 100°–101° F. The blood must be aspirated from the joint and a firm pressure bandage applied. If this fails to prevent the re-collection of blood in the joint, the incision should be reopened and the bleeding vessel sought and ligated.

Damage to the infrapatellar branch of the saphenous nerve

The scar of the medial incision sometimes remains sensitive to touch. This is due to the small branches of the infrapatellar branch of the saphenous nerve becoming caught up in the scar tissue. Occasionally a small neuroma is formed. If the main branch is divided, an area of anaesthesia over the tibial tuberosity is left, which may be a disability to anyone who has to kneel at work.

Sepsis

The complication of sepsis after this operation can lead to such disastrous results that every possible aseptic precaution should be taken, including the "no-touch" technique.

If there is any failure of part of the skin wound to heal by first intention, the knee should be kept splinted and bed-rest continued until healing is complete.

If there is clinical evidence of an infection in the knee joint, aspiration and culture of the fluid must be performed urgently so that the sensitivity of the organism to the common antibiotics may be discovered. It is wise to inject 5 ml. of a solution containing penicillin 1 000 000 units and 1·0 g. streptomycin in 15 ml. of saline immediately after the aspiration, and to give systemic therapy with a suitable antibiotic.

[*The illustrations for this Chapter on Excision of a Semilunar Cartilage of the Knee were drawn by Mr F. Price.*]

Reference

Smillie, I. S. (1946) *Injuries of the Knee Joint*. Edinburgh: Livingstone.

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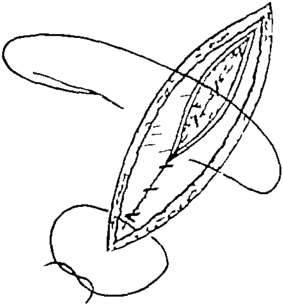

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SUPRACONDYLAR OSTEOTOMY OF THE FEMUR

ROBERT ROAF M.A., F.R.C.S. (ENG.), F.R.C.S. (ED.) M.CH. (ORTH.), B.M., B.CH., D.R.C.O.G.

Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry
Lecturer in Orthopaedic Surgery at the University of Liverpool

PRE-OPERATIVE

Indications

Supracondylar osteotomy is the simplest and quickest way of correcting deformities in the region of the knee-joint between the ages of 18 and 30 years. Below the age of 18 such deformities are usually better corrected by partial epiphysiodesis (stapling) while above the age of 30 it is usually better to perform a tibial osteotomy. The reason for this is that the joint distal to an osteotomy or fracture is always adversely affected, though in young patients the effect is usually only temporary. After the age of 30 the knee may not be sufficiently resilient to recover from the deleterious effects of a supracondylar osteotomy and permanent joint stiffness may result. In children and young adults a supracondylar femoral osteotomy is to be preferred as it makes the transverse axis of the knee-joint horizontal, while a tibial osteotomy leaves the transverse axis of the knee-joint oblique. Tibial osteotomy is, therefore, less successful in restoring normality but it is to be preferred in older patients whose knees have less power of recuperation. The upper age limit of 30 is, of course, an arbitrary and approximate average: some people have "young" knees at 40, others are "old" at 20. As it is the condition of the patient's knee rather than his age which matters each case must be assessed on its merits.

For very severe knock-knee in patients below the age of 18 or where epiphysiodesis is considered undesirable, supracondylar osteotomy may be indicated, although epiphysiodesis is usually the treatment of choice in children under the age of 18.

If the knee-joint itself is grossly abnormal as well as being deformed the deformity is usually best corrected by an intra-articular arthrodesis.

The commonest indication is genu valgum: this is usually "idiopathic" or postural and occurs in fat children. Occasionally it is a sequel of poliomyelitis, or rickets, or may follow partial destruction from infection or trauma of the lower femoral epiphysis.

Genu varum is, on occasion, bad enough to require operative correction, but in such cases the upper tibial epiphysis is often at fault so that a tibial osteotomy may be indicated even in childhood.

In severe genu recurvatum, due to a combination of weakness of the hamstring muscles and an equinus deformity of the foot, supracondylar osteotomy may be required, but the effect of correcting the equinus deformity should be seen first.

In genu flexum (due either to poliomyelitis or spastic paralysis) the effect of transplanting the hamstring muscles into the lower end of the femur should be tried before resorting to an osteotomy of the bone.

Principle

It is easy to divide a bone: the problem is to fix the two pieces of bone accurately in the desired position. This is most easily achieved by the technique of osteotomy-osteoclasis (Moore 1947) in which a wedge of bone is excised from the convex aspect of the bone but the bone is not completely divided until a fortnight later when "sticky" callus has formed.

Pre-operative preparation and anaesthesia

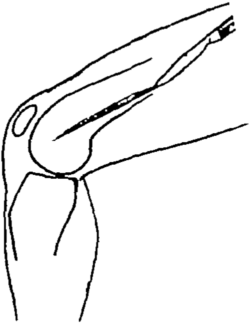
These are the same as for Arthrodesis of the knee (see page 292)

THE OPERATION

Incision

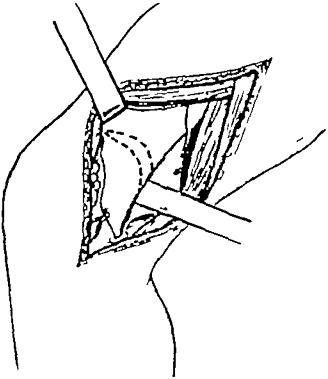
1 The incision is made in the longitudinal axis of the limb it is about 5 inches long and centred just above the adductor tubercle. If the operation is for the correction of a valgus deformity the incision is made on the medial aspect of the limb just in front of the saphenous nerve and vein, but if the operation is for genu varum the incision should be made on the outer side of the limb

In the subsequent description it is assumed that the operation is to correct a valgus deformity



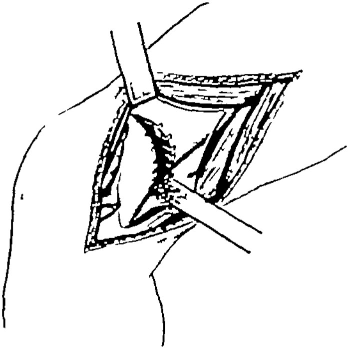
Exposure of femur

2 The deep fascia is divided in the line of the skin incision the vastus medialis and adductor magnus muscles are separated, exposing the medial aspect of the lower end of the femur The anastomosis between the highest genicular artery and the medial superior genicular artery may require ligation. The periosteum is incised and elevated and bone levers are inserted subperiosteally The site of osteotomy should be about 1 inch above the adductor tubercle. The next step is to remove a wedge of bone with its apex at the opposite cortex. The dotted lines in the illustration indicate the base of the wedge. If there is an element of either genu flexum or recurvatum the apex should be correspondingly posterior or anterior



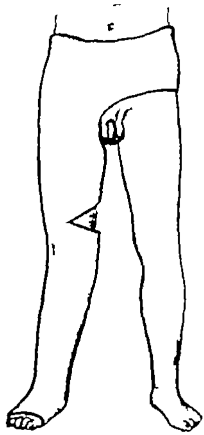
Removal of bone wedge

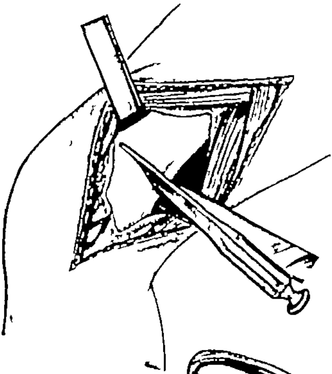
3 The wedge of bone must be carefully removed the initial cuts can be made either with a saw or with an osteotome after preliminary drilling of the cortex. Great care must be taken not to split the bone it is usually safer to remove the deeper parts of the bone-wedge with gouge forceps. Bone should be removed until approximately one-fifth of the cortex is left, then holes are drilled in this "hinge" until it is slightly flexible. The gap in the bone is then filled with bone chips, preferably of the cancellous type. The wound is closed in layers, a firm, well-padded dressing applied and the tourniquet removed. A full-length single plaster spica is applied from the iliac crest to the toes.



Plaster spica

4 Ten to 14 days later a wedge is cut from the medial aspect of the plaster just above the knee, corresponding to the gap in the bone. In the original description of the procedure this step was deferred until 8 weeks after operation, but by then the callus may be too strong to be easily bent. There is usually sufficient callus of the right consistency at the end of 10 days in a young child or 14 days in an older child. If the wound is healed the stitches are removed the deformity is now easily corrected by bending the bone to the correct shape and the plaster spica reconstituted. The limb is held in the plaster in this position until bone union has occurred complete consolidation of the fracture usually takes 6–10 weeks. Knee movement usually returns quickly without special treatment after removal of the plaster but occasionally in an apprehensive child, attendance in the physiotherapy department will be necessary.

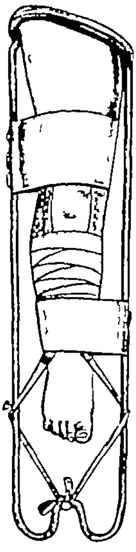




MACEWEN S OSTEOTOMY

Division of the bone

5 The method of MacEwen is a refinement of the classical operation of supracondylar osteotomy of the femur In it the bone is approached in the same way but a shorter incision is used. A linear transverse osteotomy is then made 1¼ inches above the epiphyseal line. The osteotomy cut is deepened until the bone has been three-quarters divided The osteotomy is now withdrawn and fracture of the bone is completed by manual osteoclasis. (MacEwen used a special osteotome made of steel, specially tempered to his requirements, *see* illustration.)



The splint

6 The leg is then immobilized either in a plaster of Paris spica or in a Thomas splint, in which the leg is fixed by traction with below-knee skin extensions. The correction of the valgus deformity is achieved by two wide flannel bandages, the upper of which encircles the lateral bar of the splint and limb at the level of the osteotomy while the lower encircles the ankle and inner bar of the splint. The leg must remain splinted in the correct position until the osteotomy has united.

Great care is necessary by both clinical and radiological examination to ensure that the osteotomy unites in the desired position and particularly to avoid backward angulation or a rotatory deformity at the site of the osteotomy

Reference

Moore J. R. (1947). *J Bone Jt Surg* 129 119

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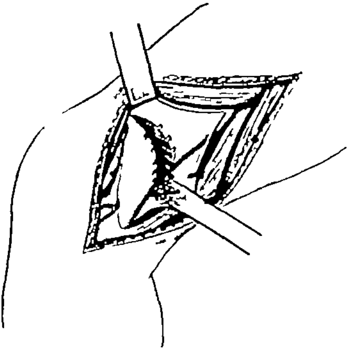

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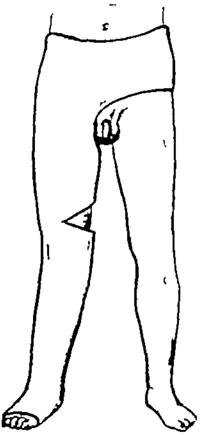

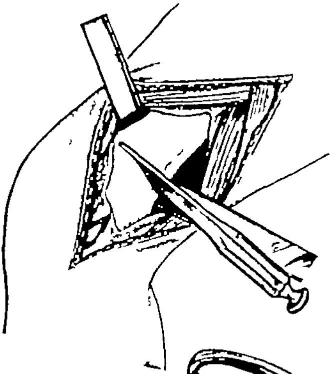

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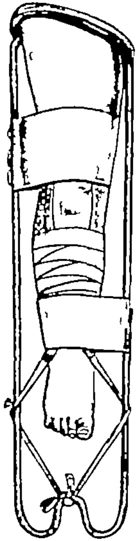

The splint

6 The leg is then immobilized either in a plaster of Paris spica or in a Thomas splint, in which the leg is fixed by traction with below-knee skin extensions. The correction of the valgus deformity is achieved by two wide flannel bandages, the upper of which encircles the lateral bar of the splint and limb at the level of the osteotomy while the lower encircles the ankle and inner bar of the splint. The leg must remain splinted in the correct position until the osteotomy has united.

Great care is necessary by both clinical and radiological examination to ensure that the osteotomy *unites in the desired position and* particularly to avoid backward angulation or a rotatory deformity at the site of the osteotomy.

Reference

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REMOVAL OF LOOSE BODIES FROM THE KNEE

M. S. Brett F.R.C.S.

Senior Registrar The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

When a loose body is responsible for attacks of pain, locking and swelling, it should be removed. Damage to the articular surfaces and the development of osteoarthritis is thereby minimized.

Contra-indications

In the absence of symptoms a loose body should not be removed.

If the knee is severely osteoarthritic a loose body should be removed only when the symptoms are clearly attributable to its presence, and not to the other osteoarthritic changes.

Pre-operative preparation

The pre-operative preparation is the same as for the removal of a semilunar cartilage (see page 261) It is wise to examine the knee by radiography immediately before the operation to localize the loose body accurately

Position of patient

The patient lies supine with a sandbag beneath the knee. This allows free manipulation of the leg while inspecting different parts of the joint. If the posterior compartment is to be exposed the knee should be in 90 degrees flexion.

Anaesthesia

General anaesthesia is satisfactory The operation should be performed with a bloodless field using an Esmarch bandage and tourniquet (see Volume 1 Part I page 89)

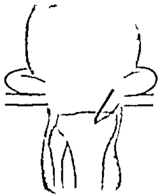
THE OPERATION

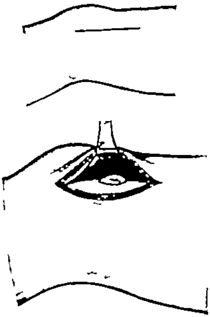
The incision depends on the site of the loose body In the case of osteochondritis dissecans the crater should be inspected, if necessary through a second incision.

Exploration of intercondylar notch

1

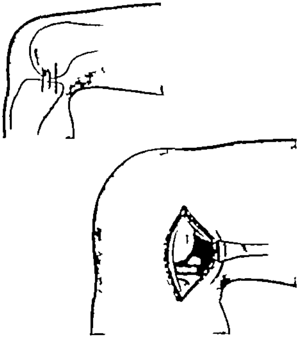
A loose body which lies in the intercondylar notch is removed through the same incision as for the removal of a medial semilunar cartilage The femoral condyle is inspected, and if there is a crater as in osteochondritis dissecans, the ragged edges should be trimmed. If the loose body is much smaller than the crater a search should be made for a second loose body An inspection should also be made of the anterior horn of both semilunar cartilages, as there may be a coexistent tear of one of them.





Exploration of suprapatellar pouch

2 If the loose body in this situation is attached or can be localized between finger and thumb, it should be removed through an incision placed directly over it. If it is very mobile and cannot be held through the skin, the anteromedial compartment should be opened and the loose body massaged down from the suprapatellar pouch.



Exploration of posterior compartment

3 It is important to determine by radiography immediately before the operation whether the loose body lies on the medial or the lateral side

The loose body is approached from the appropriate side through an incision similar to that for the removal of the posterior horn of a semilunar cartilage. A retractor is inserted above the cartilage to expose the posterior compartment. On the lateral side the tendon of popliteus will be seen. The lateral popliteal nerve is avoided by keeping the incision anterior to the biceps tendon.

POST-OPERATIVE CARE AND COMPLICATIONS

These are the same as for the removal of a semilunar cartilage from the knee (see page 267)

[*The illustrations for this Chapter on Removal of Loose Bodies from the Knee were drawn by Mr F Price and Mr J Whelden*]

REMOVAL OF LOOSE BODIES FROM THE KNEE

M. S. Brett F.R.C.S.

Senior Registrar The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

When a loose body is responsible for attacks of pain locking and swelling it should be removed. Damage to the articular surfaces and the development of osteoarthritis is thereby minimized.

Contra-indications

In the absence of symptoms a loose body should not be removed.

If the knee is severely osteoarthritic a loose body should be removed only when the symptoms are clearly attributable to its presence, and not to the other osteoarthritic changes.

Pre-operative preparation

The pre-operative preparation is the same as for the removal of a semilunar cartilage (*see* page 261) It is wise to examine the knee by radiography immediately before the operation to localize the loose body accurately

Position of patient

The patient lies supine with a sandbag beneath the knee This allows free manipulation of the leg while inspecting different parts of the joint. If the posterior compartment is to be exposed the knee should be in 90 degrees flexion.

Anaesthesia

General anaesthesia is satisfactory The operation should be performed with a bloodless field using an Esmarch bandage and tourniquet (*see* Volume 1 Part I, page 80)

THE OPERATION

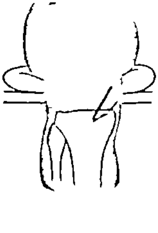
The incision depends on the site of the loose body In the case of osteochondritis dissecans the crater should be inspected, if necessary through a second incision.

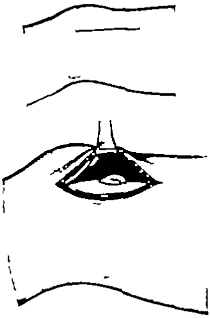
Exploration of intercondylar notch

1

A loose body which lies in the intercondylar notch is removed through the same incision as for the removal of a medial semilunar cartilage. The femoral condyle is inspected, and if there is a crater as in osteochondritis dissecans, the ragged edges should be trimmed. If the loose body is much smaller than the crater a search should be made for a second loose body

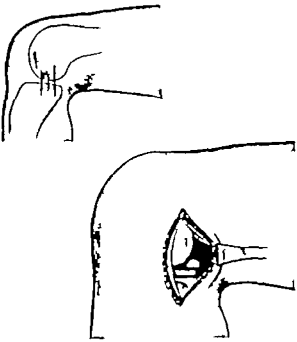
An inspection should also be made of the anterior horn of both semilunar cartilages, as there may be a coexistent tear of one of them.





Exploration of suprapatellar pouch

2 If the loose body in this situation is attached or can be localized between finger and thumb, it should be removed through an incision placed directly over it. If it is very mobile and cannot be held through the skin, the anteromedial compartment should be opened and the loose body massaged down from the suprapatellar pouch.



Exploration of posterior compartment

3 It is important to determine by radiography immediately before the operation whether the loose body lies on the medial or the lateral side.

The loose body is approached from the appropriate side through an incision similar to that for the removal of the posterior horn of a semilunar cartilage. A retractor is inserted above the cartilage to expose the posterior compartment. On the lateral side the tendon of popliteus will be seen. The lateral popliteal nerve is avoided by keeping the incision anterior to the biceps tendon.

POST-OPERATIVE CARE AND COMPLICATIONS

These are the same as for the removal of a semilunar cartilage from the knee (see page 257)

[The illustrations for this Chapter on Removal of Loose Bodies from the Knee were drawn by Mr F Price and Mr J Wheldon]

INTERNAL FIXATION FOR FRACTURES OF THE PATELLA

ROBERT ROAF M.A., F.R.C.S. (ENG.), F.R.C.S (ED), M.CH. (ORTH.) B.M., B.CH., D.R.C.O.G.
Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry
Lecturer in Orthopaedic Surgery at the University of Liverpool

PRE-OPERATIVE

Indications

The commonest indication is a recent transverse fracture with separation of the fragments—especially in young people where the patella was normal before the accident.

Contra-indications

The method is not suitable for comminuted fractures or for transverse fractures in elderly people whose knees already show arthritic changes, or where the patella is already abnormal—for example, where it is the site of Paget's disease or marked chondromalacia. It is not recommended for old-standing fractures with marked separation of the fragments and a long fibrous union.

Pre-operative preparation

Normally operation should be performed as soon after the injury as possible but if there are abrasions or any local skin infection, these must be well healed before operation. As with other knee operations, the whole leg up to the groin and including the toes is shaved, washed and sprayed three times with a suitable antiseptic. The skin preparation should preferably commence 48 hours before operation. During this period it is often advisable, for comfort, for the patient's leg to be rested in a metal back splint.

In the post-operative period it will be important to secure the patient's co-operation. Accordingly before operation, he should be told that after operation his knee will have to be held straight for some 6 weeks until the fracture is united. During this time, the knee will tend to become stiff, intra-articular and extra articular adhesions may form, the quadriceps muscle will waste and lose strength and elasticity. All these things can be largely avoided if the patient performs frequent, regular quadriceps contractions. These must be taught before operation and the reason for doing them should be explained to the patient.

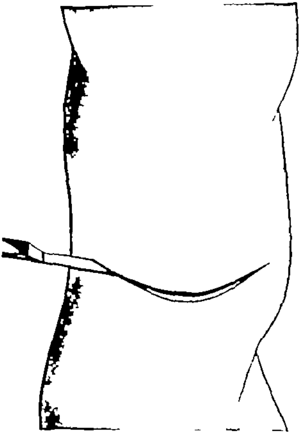
Anaesthesia

General anaesthesia is preferable, although it is possible to use local anaesthesia. It is advisable to apply a tourniquet high up on the thigh after exsanguinating the limb with an Esmarch bandage.

Position of patient

The patient is placed supine with the knee straight and the patella pointing to the ceiling. The operator stands at the side of the table on the same side as the affected leg. The whole limb is draped in a roll of sterile stockinet. Before rolling the stockinet up the leg the skin around the site of the incision is painted with an adhesive so that the stockinet will adhere to the skin in this region.

THE OPERATION

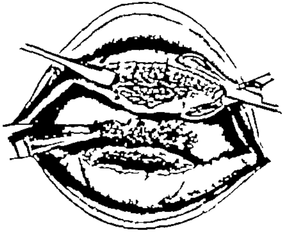


The incision

1 A slightly curved transverse incision 4 inches long is made on the anterior aspect of the knee. The ends of the incision should be at the level of the middle of the patella the middle of the incision should be at the level of the lower pole of the patella. During flexion and extension the skin on the anterior aspect of the knee slides in relation to the aponeurosis. The line of the skin incision is designed so that it will not overlap the suture line in the deep fascia and the chances of the skin and deep fascia becoming adherent are reduced.

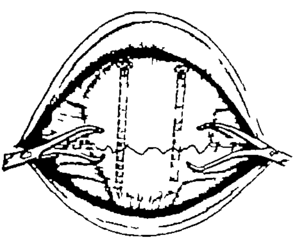
Exposure of the fractured patella

2 The upper skin flap is elevated and retracted. In this region the superficial and deep fasciae are separated by loose areolar tissue and the skin flap can be elevated mainly by blunt dissection with only occasional use of a knife. The fractured patella and torn aponeurosis are now displayed. The blood clot is removed, both from the fractured surfaces and from the joint. The raw areas of the bone are freshened by gently scraping with a sharp spoon.



Reduction of fracture and fixation with screws

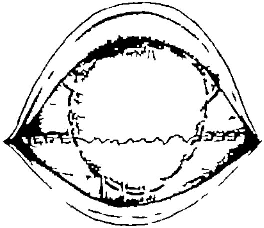
3 The bone fragments are now reduced It is important that there should be perfect apposition, especially of the articular surface. If there is any angulation at the site of fracture the angle should point forwards, not backwards. If there is any backward angulation this will lead to permanent roughness and later arthritic changes. If there is a slight forward angulation this will fill up with fibro-cartilage and is unlikely to lead to a later degenerative arthritis. The bone fragments are held in position by two towel clips applied to each side Two drill holes are then made vertically through the patella and suitable Vitallium screws inserted. The screws must be long enough to perforate the opposite cortex and should be screwed up tightly so that the two pieces of bone are compressed together In addition, the torn lateral aponeuroses are sutured with strong interrupted sutures.



Alternative methods

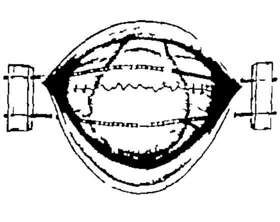
Circumferential suture

4 A circumferential suture is inserted round the patella. With this method it is harder to maintain perfect apposition and compression of the fragments.



Apposition by wire tension

5 A stainless steel wire, 2 mm. in diameter is drilled transversely through the upper piece of the patella a similar wire is inserted into the lower piece of the patella parallel to the upper wire The wires are clamped together by sliding over their ends small perspex blocks with two parallel holes drilled in them the holes are ¼ inch closer together than the wire holes in the patella consequently the tension of the wire forces the two fragments of bone together In addition, the lateral aponeurosis is sutured and, if desired, a circumferential stitch can be inserted. The skin is sutured without drainage



POST-OPERATIVE CARE AND COMPLICATIONS

A sterile gauze dressing is placed on the wound. Over this a copious cotton wool dressing is applied this should encircle the limb completely and extend from 3 inches below to 4 inches above the articular surface of the tibia. The dressing is held in place by two firmly applied 6-inch crepe bandages. The tourniquet is now removed the surgeon waits until the toes become pink and a well-padded metal back splint is applied and fixed firmly in position it should reach from 2 inches below the fold of the buttock to 2 inches above the medial malleolus.

Quadriceps exercises and straight leg raising are practised regularly from the time the patient regains consciousness. On the twelfth day the bandages and dressings are removed if the wound is healed the sutures are taken out and a skin-tight plaster is then applied. If the Kirschner wire technique has been used a hole must be cut in the plaster on each side to allow the wires to move when the patient contracts his quadriceps. The plaster should extend from just below the buttock to just above the ankle, the malleoli having been previously protected by a strip of felt. The patient can get up in this plaster Four weeks from operation the plaster is bi-valved. The Kirschner wires, if present, are removed. The patient now starts non-weight bearing flexion-extension exercises under supervision, but wears his plaster for weight bearing. The intensity of the exercises is gradually increased provided always that the patient can fully extend his knee actively If he loses this power he should not be allowed to flex his knee any farther until he has regained full active extension. The plaster cylinder is finally abandoned either after 8 weeks or when the patient can flex his knee to 90 degrees and extend it fully against resistance—whichever is the longer It is usually 4–6 months before the knee can be fully flexed.

With the above post-operative regime complications are few but occasionally with an apprehensive or unco-operative patient, the knee remains stiff. In addition to physiotherapy intra-articular injections of hydrocortisone and streptokinase may be helpful occasionally a forcible manipulation of the knee under anaesthesia helps but this requires great care and should not be done less than 4 months from the operation. If too much force is used, re-fracture of the patella, rupture of the quadriceps or ligamentum patellae or a supracondylar fracture of the femur may result. If the patient tries to walk too soon without the bi-valved plaster cylinder he may stumble and re fracture the patella. This requires further operative repair of the quadriceps mechanism.

[*The illustrations for this Chapter on Internal Fixation for Fractures of the Patella were drawn by Mr F Price from originals by Mr John Aston F R.C.S*]

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EXCISION OF THE PATELLA

ROBERT ROAF M.A., F.R.C.S. (ENG.) F.R.C.S (ED), M.CH. (ORTH.) B.M., B.CH., D.R.C.O.G.

Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry
Lecturer in Orthopaedic Surgery at the University of Liverpool

PRE-OPERATIVE

Indications

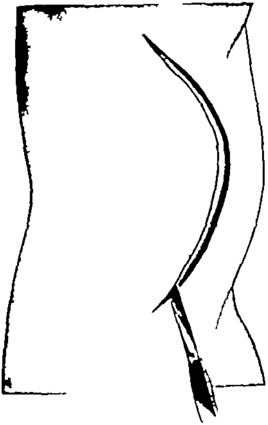
The common indications are stellate and comminuted fractures, some transverse fractures (especially in the elderly) neglected transverse fractures with marked separation of the fragments, advanced chondromalacia, osteo-arthritis localized to the patello-femoral compartment of the knee joint and recurrent subluxation with degeneration of the articular surface (usually combined with downward and medial transplantation of the tibial tubercle) There are also certain rare indications such as bone cysts, Paget's disease tuberculous confined to the patella and giant-cell tumours.

Contra-indications

If the knee is already stiff the patella should not be excised until the knee has been mobilized—by physiotherapy manipulation and, if necessary quadriceps-plasty Excision of the patella slightly weakens the quadriceps mechanism assiduous quadriceps exercises can develop this muscle sufficiently to compensate for this for ordinary purposes but slight weakness will be apparent if the knee is subjected to severe strain as in competitive athletics or climbing ladders. In those who wish to do these things excision should be avoided if possible.

Pre-operative care

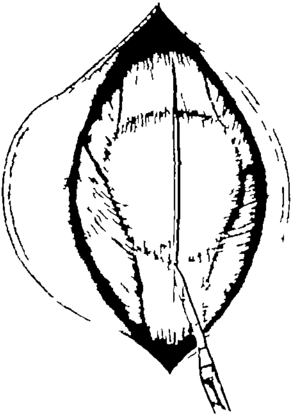
Whenever possible, excision of the patella should be done as a planned procedure. That is, before operation, the patient should be taught quadriceps drill. If the indication for excision is a chronic condition such as chondromalacia, the quadriceps muscle should be built up and maximum knee flexion obtained before operation. In the case of recent comminuted fractures, many surgeons advise immediate excision but, in recent years, an increasing number of surgeons have been advocating delayed excision, that is, immediately after the injury a back splint is applied, the patient is taught quadriceps exercises and, as soon as he can, gentle non-weight-bearing flexion movements are started. Four weeks or so later the patella is excised. Of course, if there is separation of the fragments and rupture of the lateral aponeurosis, operative restoration of the knee extension mechanism must be done without delay



THE OPERATION

Incision

1 A slightly curved incision 8 inches long is made parallel to and half an inch lateral to the lateral border of the patella. During flexion and extension the skin on the front of the knee slides in relation to the aponeurosis. This incision is designed so that it does not overlap the line of incision in the deep fascia and the chances of the skin and deep fascia becoming adherent are reduced.



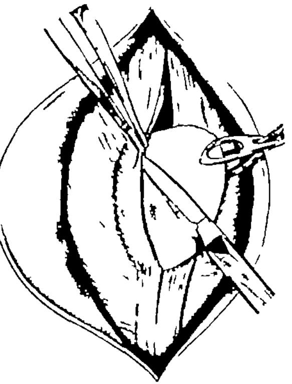
Elevation of skin flap and incision in aponeurosis

2 The medial skin flap is elevated and retracted. In this region the superficial and deep fascia are separated by loose areolar tissue and therefore the skin flap can be elevated mainly by blunt dissection with only occasional use of a knife. The deep fascia, the quadriceps tendon, the ligamentum patellae and the patella, covered by fibrous aponeurosis, are now seen. A longitudinal incision 8 inches long is made in the quadriceps tendon the aponeurosis covering the patella and the ligamentum patellae

Shelling out the patella

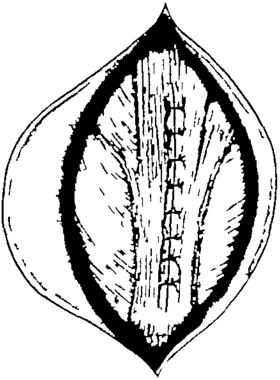
3 With a strong scalpel the superficial aponeurotic fibres are elevated from the articular surface of the patella, keeping the cutting edge of the knife close to the bone. At the same time, the quadriceps tendon is detached from the upper pole of the patella and the ligamentum patellae from the lower pole again keeping close to the bone. It is convenient to free the medial half of the patella first. During this step the assistant should retract the patella laterally and either downwards or upwards so as to put the fibres under tension. If the patella is already in pieces due to a recent fracture the fundamental technique is the same but removal is by morcellement.

A similar procedure is used to free the lateral half of the patella but now the bone is retracted medially and slightly drawn out of the wound by the assistant. Many surgeons find it helpful to stand on the opposite side of the table for this part of the operation. Blood clot, if present, is removed from inside the knee joint.



Closure

4 The longitudinal incision is sutured longitudinally—that is the quadriceps mechanism is restored to its original length. No attempt is made to shorten the knee extensor mechanism. If, as in a transverse fracture, the lateral aponeuroses of the knee are torn these are repaired but not shortened. The only exception to this rule is in an operation for an old transverse fracture where there is wide separation of the fragments with a long fibrous union under these circumstances it is justifiable to try to shorten the extensor mechanism slightly—provided the knee could be fully flexed before operation. Even so the shortening must not be overdone or knee flexion will be permanently limited. The skin is then closed without drainage.



POST-OPERATIVE CARE

This is virtually the same as after internal fixation for a fracture of the patella except that, where the lateral aponeuroses are intact, non-weight-bearing knee flexion exercises under supervision can be commenced at the fourteenth day that is the plaster can be bi-valved 3 weeks sooner than after internal fixation of a fracture. If the excision has been performed for a transverse fracture the after-treatment is the same as for internal fixation of the patella.

After excision of the patella, the surgeon has to reconcile two equally desirable but opposing aims. On the one hand, he wishes for early movement to prevent the knee becoming stiff and the quadriceps tendon becoming adherent to the femur and to prevent loss of elasticity and wasting of the quadriceps muscle. On the other hand, too early and vigorous movement may cause rupture of the suture line and permanent weakness and lengthening of the knee extension mechanism. This is obviously a greater risk if the excision has been performed for a recent fracture with separation of the fragments and tearing of the lateral aponeuroses. In all cases, quadriceps exercises must be started as soon as the patient recovers from the operation. If the excision has been done for a chronic condition such as chondromalacia, the knee is held straight on a back splint for eight to ten days. After the splint is removed for non-weight-bearing knee-flexion exercises but must still be worn for walking the splint is finally abandoned when the knee flexes to 70 degrees. In the cases of recent fracture with separation of the fragments, knee flexion should be delayed until the torn fibres of the patellar tendon have joined firmly together that is approximately 6 weeks, during which time the knee should not be allowed to bend but the patient may walk in a plaster cylinder

[The illustrations for this Chapter on Excision of the Patella were drawn by Mr F Price from originals by Mr John Aston F.R.C.S.]

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ARTHRODESIS OF THE KNEE

ROBERT ROAF M.A., F.R.C.S. (ENG.) F.R.C.S. (ED.), M.CH. (ORTH.), B.M., B.CH., D.R.C.O.G.

Director of Clinical Studies and Research at the Robert Jones and Agnes Hunt Orthopaedic Hospital Oswestry
Lecturer in Orthopaedic Surgery at the University of Liverpool

PRE-OPERATIVE

Indications

Arthrodesis of the knee is indicated in any destructive arthritis where the joint is painful, unstable or potentially dangerous, or where there is a fibrous ankylosis in bad position. The classical indication is tuberculosis of the knee joint but with modern treatment and early diagnosis this indication is becoming rare, as it is possible to restore useful movement to most early cases of tuberculous synovitis. The same applies to septic infections of the knee joint. Other indications are severe rheumatoid arthritis, advanced osteo-arthritis or following bad fractures into the knee joint, or extensive rupture of the cruciate ligaments with marked instability. In these conditions conservative treatment should be tried first and the patient fitted with a well-shaped supporting cylinder: this is important for two reasons—firstly the patient should know what it is like to have a stiff knee; also it can be seen whether his stiff knee gait throws an undue strain on his hip and ankle as these may also be arthritic and may start causing trouble if the knee is stiffened.

Secondly, many patients with painful or unstable knees can walk comfortably with a removable support and prefer to wear this, rather than to have an operation, especially if they retain some movement which enables them to sit in comfort either without the support or when wearing a hinged caliper.

Arthrodesis of the knee is sometimes recommended for paralysis of the quadriceps muscle. Actually this indication is a rare one. If the patient has strong gluteal and calf muscles he can usually walk and stand even though the quadriceps is paralysed. Even if the knee is flail the patient may find a support, such as a hinged caliper, is preferable to an arthrodesis and certainly arthrodesis should never be performed unless the patient has tried the effect of wearing a plaster cylinder and knows the disadvantages of a stiff knee.

If the knee is already stiff and very painful or unstable, the relief of pain and gain in stability will amply compensate for the loss of movement. Difficulty arises where the knee is painful but still retains useful movement. Much depends on the age of the patient. In a young patient, the result of arthrodesis will be better than in an elderly one who will not be able to adapt so well to a stiff knee and in whom the extra strain on the hip and ankle may cause pain in these joints. If it is decided to do an arthrodesis in an elderly patient, he should be taught how to put on socks or stockings with an embroidery frame, shoes with a long-handled or double shoe horn and to use elastic shoe-laces.

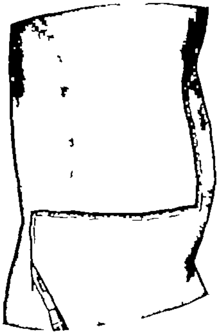
Contra-indications

It is usually inadvisable to perform an arthrodesis of the knee in young children. First, the operation may interfere with epiphyseal growth; secondly, it is usually harder to obtain arthrodesis if the epiphyses are largely cartilaginous and, lastly, even if bony ankylosis does occur flexion deformity may still occur due to the bone yielding at the epiphyseal lines. If arthrodesis is performed for tuberculous arthritis it is important to ensure that there are no active tuberculous foci elsewhere in the body and that the infection of the knee joint is in a quiescent phase. Needless to say, before and after operation it will be necessary to give full supporting treatment with antibiotics and chemotherapy.

Position of arthrodesis

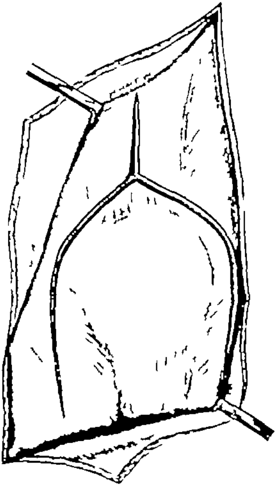
For most patients, 20 degrees of flexion from the dead straight position is desirable. This enables them to walk with a practically normal gait and to sit well back in a chair with their foot on the ground.

THE OPERATION



The incision

1 A Z-shaped incision is used. The middle limb should be 5 inches long running transversely across the front of the knee at the level of the junction of the middle and lower thirds of the patella. The superior limb runs 6 inches vertically up the limb from the medial end, the inferior limb runs 2 inches vertically down the limb from the lateral end.



Elevation of flaps and incision in deep fascia

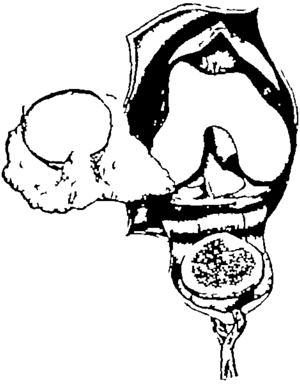
2 The flaps are elevated mainly by blunt dissection with occasional touches of the knife. An inverted Y-shaped incision is made in the deep fascia. This starts 8 inches above the upper pole of the patella and runs vertically downwards for 2½ inches dividing the quadriceps tendon in the line of its fibres. The incision then bifurcates one limb running down on each side of the patella and ½ inch away from it, continuing down to just below the level of the articular surface of the tibia.

Exposure of synovial membrane

3 The central flap consisting of deep fascia and fibrous capsule, quadriceps tendon, patellar ligament and ligamentum patellae is now elevated starting superiorly and dissecting the fibrous capsule away from the synovial membrane. When the patella is reached this is sawn through in the coronal plane leaving the posterior half with its articular surface attached to the synovial membrane.

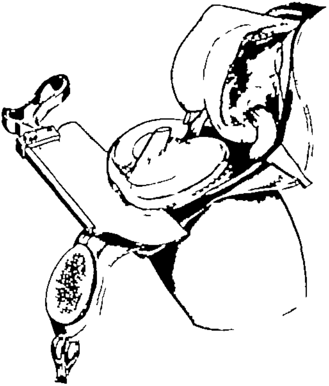
Excision of synovial membrane

4 The synovial membrane is now excised as completely as possible, flexing the knee in order to obtain access to the posterior portions. It may be wise to excise the collateral ligaments if the synovial membrane is adherent to them, and it is nearly always necessary to divide the cruciate ligaments in order that the head of the tibia can be pulled forward leaving the popliteal vessels and nerves well away from the head of the tibia so that the risk of damaging them is minimized. Any caseous foci are lightly curetted. The synovial membrane is of course, sent for microscopic examination and bacteriological culture



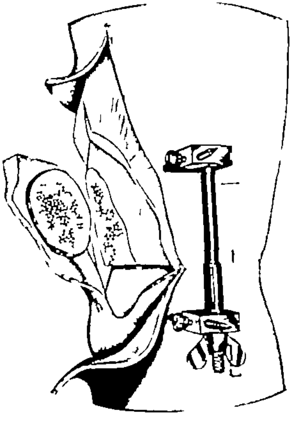
Excision of articular surface

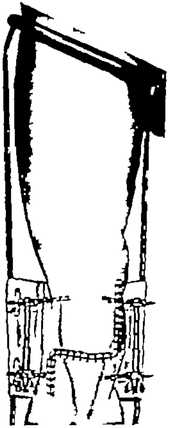
5 First the anterior aspect of the articular surface of the femur is excised. Then the inferior articular surface of the femur and superior articular surface of the tibia are excised. It is best to use a saw to cut through three-quarters of the bone and complete the division with a fine osteotome. The planes of the resection are arranged in such a manner that when the two flat surfaces are in firm contact in the sagittal plane the long axis of the tibia is at 160 degrees to the long axis of the femur—in other words the tibia is flexed 20 degrees from the completely straight position. In the coronal plane the femur and tibia should meet at 170–175 degrees, that is, there should be a slight valgus equivalent to the natural valgus on the opposite knee. If there are any caseous foci these are lightly curetted out.



Fixation in compression

6 The two bones are then locked together in compression this is achieved by inserting a 4-mm. Steinmann pin in the femur and the tibia running in the coronal plane and parallel to each other The two Steinmann pins are then fixed together with Charnley's special clamps which are tightened until there is firm pressure between the bone ends of approximately 15–20 pounds to the square inch. The pins should be inserted mid-way between the anterior and posterior surfaces of the bone, otherwise when tightening the clamps the angle may be altered, the knee will either extend or flex and firm contact over the whole of the raw area will not be obtained. If there is any difficulty in maintaining firm uniform contact a second pair of pins may be inserted but it is important that the more posterior pins do not injure the lateral popliteal nerve.





Closure of wound

7 The wound is closed in layers without drainage. After applying the usual pressure dressing as described above, the leg is placed in a Thomas splint but without traction.

A light plaster cylinder may also be employed to make fixation doubly secure. In the illustration, dressings, bandages and plaster are omitted for the sake of clarity

POST-OPERATIVE CARE

The leg is kept in the Thomas splint for a fortnight, at the end of which time the sutures are removed and a well fitting plaster cylinder is applied from the groin to the ankle, and the patient moves his leg in bed. At the end of a further fortnight the Steinmann pins are removed and the patient is allowed to start walking Union is usually complete 8–10 weeks after operation when the plaster can be removed. Before finally dispensing with plaster the degree of union must be confirmed by clinical and radiological examination.

[The illustrations for this Chapter on Arthrodesis of the Knee were drawn by Mr J Wheldon from originals by Mr John Aston F.R.C.S]

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OPERATIONS FOR INGROWING TOE NAIL

AND SUBUNGUAL EXOSTOSIS

M. S. Brett F.R.C.S.

Senior Registrar The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

INGROWING TOE NAIL

Indications

Operative treatment for ingrowing toe nail is indicated only when the lesion has failed to respond to proper nail care and attention to footwear Two operations are available (1) lateral wedge resection of the nail and nail bed and (2) radical removal of the nail and nail bed.

The latter operation is indicated if there is deformity of the nail or if there has been repeated infection on both sides of the nail bed.

Special contra-indications

Ischaemia of the foot is the most important contra-indication to operation.

Pre-operative preparation

If infection is present the patient should rest in bed for a few days before operation. If pus has spread under the nail, the latter should be avulsed and further operation deferred for a week.

Anaesthesia

General anaesthesia or local digital nerve block are both satisfactory A rubber tourniquet is placed round the base of the toe

REMOVAL OF SUBUNGUAL EXOSTOSIS

(*Not illustrated*)

Indications

Operation is indicated in the presence of pain which cannot be relieved by attention to the shoes.

Contra-indications and anaesthesia are as for operation upon ingrowing toe nail (*see above*)

The operation

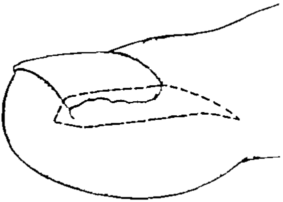
The nail is removed and the pale dome-shaped exostosis is revealed. It is covered with a very thin layer of soft tissue and is easily removed with bone nibblers. The wound is dressed with tulle gras and allowed to granulate There is no special post-operative care, although a short plaster will allow walking without discomfort.

THE OPERATION

WEDGE RESECTION OF THE NAIL AND NAIL BED

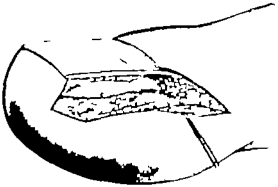
The incision

1 A longitudinal incision is made through the nail $\frac{1}{8}$ inch from the side of the lesion. This extends proximally through the nail fold to the base of the nail. A parallel incision is made through the skin by the side of the lesion extending down to the phalanx. This extends proximally as far as the first incision and joins it laterally



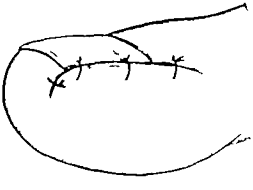
Excision of tissue

2 The wedge of tissue between these incisions is then excised cleanly to expose the bare bone of the phalanx. Care must be taken to see that the corner of the germinal part of the nail bed is completely excised from the base of the phalanx. It curves sideways round the border of the phalanx, which is very wide at its base.



Closure

3 Two or three interrupted sutures are inserted to close the gap that is left.

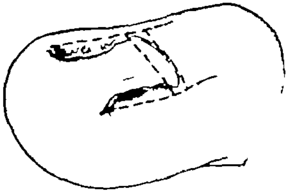


RADICAL REMOVAL OF THE NAIL BED

There are several ways in which this operation may be done. The essential step in all of them is the complete removal of the germinal part of the nail bed. The difference between them is the way in which healing of the raw area is obtained. A method that is simple and that interferes least with the shape and function of the toe is the one of choice.

Method avoiding shortening of the toe (Zadik)

4 This operation is based on the fact that the germinal part of the nail bed does not extend distal to the lunula.

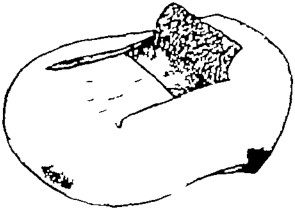


Nail avulsion

The nail is avulsed. The nail folds are excised and a small skin flap is raised by making an incision proximally from each corner of the eponychium and by excising the free edge of the eponychial fold.

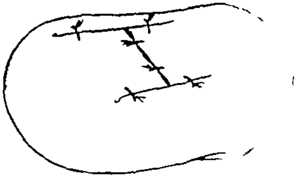
Removal of nail bed

5 The nail bed proximal to the lunula is removed entirely. It is most important to follow the nail bed laterally at the base of the phalanx and to make sure that it is completely dissected from the bone, to which it is very adherent. Failure to do this will result in the growth of a small piece of nail which may cause symptoms later. The bone should be thoroughly scraped with a sharp spoon or rugine so that no soft tissue is left behind except the extensor tendon insertion.



Closure

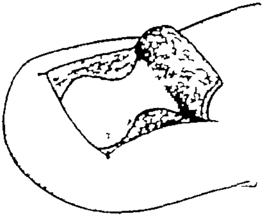
6 The skin flap is advanced and sutured to the proximal edge of the remaining nail bed. If the flap cannot be sutured without tension, a free split-skin graft should be used to cover the raw area.



Method involving partial amputation of terminal phalanx

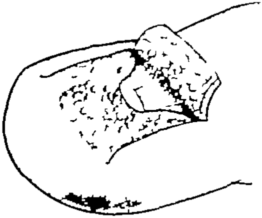
Exposure of terminal phalanx

7 After a first step identical with that of the previous operation, the nail bed is completely excised to expose the terminal phalanx. The germinal layer is excised as before



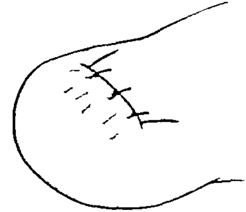
Amputation of phalanx

8 The phalanx is trimmed back with bone nibblers.



Closure

9 The plantar skin and fat are brought over the stump of the phalanx and sutured to the proximal flap It is very difficult to do this neatly but healing is usually no problem unless there is tension on the skin edges.



POST-OPERATIVE

The sutures are not removed for 12 days. It is preferable for the patient to remain in bed with the foot elevated for a week to aid primary healing If there are strong reasons why the patient should not stay in bed, a short walking plaster will allow reasonable activity without discomfort.

[*The illustrations for this Chapter on Operations for Ingrowing Toe Nail were drawn by Mr F Price.*]

Reference

Zadik, F R. (1950). "Obliteration of the Nail Bed of the Great Toe without Shortening the Terminal Phalanx." *J Bone Jt Surg* 32B, 66.

SPIKE ARTHRODESIS FOR HAMMER TOE

K. I. Nissen F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

The main element of the deformity is fixed flexion of the proximal inter-phalangeal joint. The second toe is the one most commonly affected. Conservative treatment is tedious and unprofitable.

In the method of correction by arthrodesis devised by Higgs, the head and neck of the proximal phalanx are fashioned into a blunt peg, roughly square in cross-section, which is firmly impacted into a round hole drilled through the base and into the medulla of the intermediate phalanx. The surfaces of cancellous bone unite so rapidly that the light splintage can be discarded after two weeks. A minor disadvantage of this technique is the reduction in the over-all length of the toe by the amount of impaction. When even this amount of shortening must be avoided, usually for a cosmetic reason, a conservative excision of the joint with internal fixation for from six to eight weeks by a removable Kirschner wire may be employed.

Indications

In children painful symptoms are unusual and the deformity itself is the usual reason for operation An additional reason for straightening of a second toe is to provide lateral support for the great toe and so help to control incipient hallux valgus. Whenever possible the operation is deferred until growth has nearly ceased.

In adults a painful dorsal corn is the common indication A terminal callosity near the nail margin may also give discomfort. When hammer deformity of the second toe is associated with advanced hallux valgus, the great toe has to be dealt with first in order to make room for the second toe in its normal position.

All four outer toes together may present the deformity and may be treated by spike arthrodesis. Such a case should not be confused with the clawing of all five toes associated with pes cavus.

The little toe is often better treated by other procedures such as free resection of the joint, excision of the whole of the proximal phalanx, or even amputation.

Mallet toe deformity at the distal joint of a toe can be treated by the spike technique in miniature but the small bones are difficult to manipulate and to control.

Contra-indications

Local sepsis —Infection of the bursa often present under a dorsal corn must be allowed to subside before a spike operation can be entertained. Occasionally a low-grade septic arthritis develops and leads to a chronic sinus as a rule the correct treatment is free resection of the bone ends.

Associated dislocation of the metatarso-phalangeal joint.—The first surgical procedure to consider is excision of the metatarsal head.

Associated gross hallux valgus unsuitable for correction —Either free resection of the joint or amputation of the toe and the use of a soft rubber "spacer" may be indicated.

Flexion deformity above a right angle —The contracture of the soft tissues may be too great for spike arthrodesis. Again free resection or amputation may give relief.

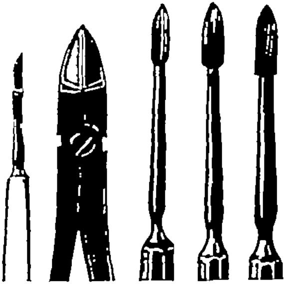
Old age —By itself old age is not a contra-indication, though the operation is seldom performed on patients over the age of 70 years.

Anaesthesia

Local anaesthesia can be used, but a general anaesthetic permits the free use of an exsanguinating tourniquet—a great advantage

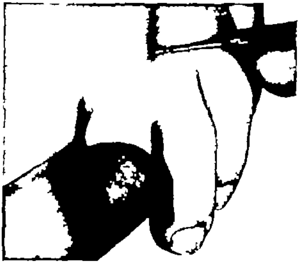
THE OPERATION

Special instruments



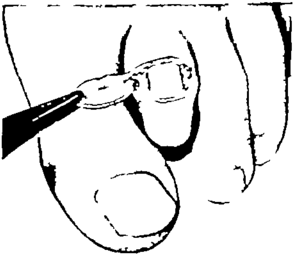
1 Instruments required for the operation are a fine tenotome a small bone cutter preferably Stamm's model in which the cutting edges are arranged like two approaching osteotomes, and Paton's burrs in different sizes. Thick collodion is necessary for splintage purposes.

Extensor tenotomy



2 The extensor tendons, which are usually taut, are divided subcutaneously and the metatarso-phalangeal joint is fully flexed. This makes sure that the toe, after it has been straightened, will have no tendency to stay cocked up above its neighbours. It is a common error to think that this step can be omitted because the tendons are divided at a later stage in the operation.

Excision of the dorsal corn



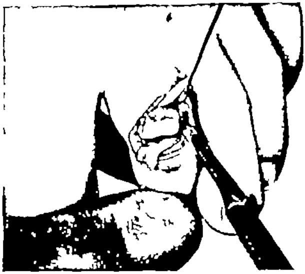
3 A transverse ellipse of skin is removed over the joint and with it most of the dorsal corn. The ends of the incision should not encroach on the plantar half of the toe. This reduces the risk of damage of the digital vessels and nerve The width of the ellipse becomes important at the end of the operation. If too wide, closure of the incision is difficult if too narrow the additional stability given by firm skin tension is lost. It is better to err on the narrow side at first because more skin can be removed later

4

Division of the extensor tendon and release of lateral ligaments

The sides of the extensor tendon are defined with a scalpel It is divided obliquely and each end is turned back. The reason for conserving the tendon is to retain extensor control over the terminal phalanx and avoid a secondary mallet toe deformity

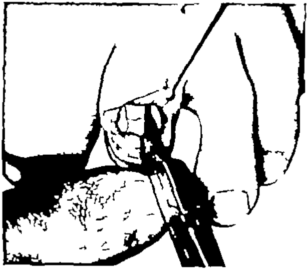
The contracted lateral ligaments may be seen as narrow white bands, one on either side of the head of the proximal phalanx. They are released by a narrow scalpel inserted edge upwards alongside the bone. By the end of this stage the head and neck of the proximal phalanx are completely denuded of soft tissues. The toe is then pulled out straight so as to overcome any remaining contracture.



5

Resection of the condyles

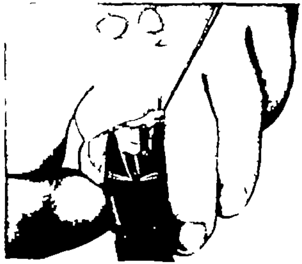
The whole of each condyle is removed with a Stamm s bone cutting instrument. This reduces the width of the end of the bone to about a third. A sharply pointed spike will tend to break or to disimpact and must be avoided at all costs.



6

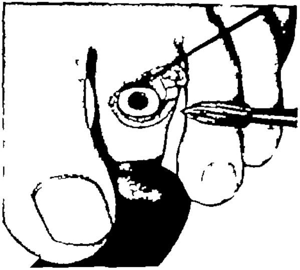
Further trimming of the spike

The curved underneath part of the head is next removed In this way the cortical bone of a dorsal strip of the head and neck is carefully preserved. It strengthens the spike, the rest of which, except for a small square of articular cartilage at the very end, is all cancellous bone



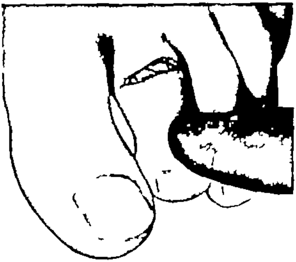
Drilling of the intermediate phalanx

7 A Paton's burr of appropriate size is chosen. The sharp point is made to enter the base of the phalanx just to the plantar side of centre. The instrument is held with a slight inclination towards the dorsum of the toe and a deep round hole is drilled into the medullary cavity of the shaft. The slight dorsal inclination of the hole ensures that the joint is arthrodesed in a few degrees of flexion, resembling the normal attitude of the toe at rest.



Impaction

8 The square peg is firmly impacted into the round hole by controlled backward pressure on the intermediate phalanx. The stability of the impaction is tested by gently tapping the toe as shown. The cut ends of the extensor tendon are replaced and the incision is closed with three or four sutures. Slight tension of the skin at this stage favours stability



Splintage

Gauze

9 Two strips of soft gauze are cut. One is arranged loosely over the proximal phalanx with the ends held back lightly under the sole. The other is placed under the intermediate and distal phalanges and round the end of the toe, with the ends held back on the dorsum. The four ends are secured by a slack turn of elastic adhesive bandage.

10 *Collodion*

A small quantity of really thick collodion is poured over the gauze on the dorsum of the toe and allowed to set.

NOTE.—Painful and dangerous constriction of the toe may occur later from oedema or from contraction of the blood-soaked gauze. For this reason the gauze strips must not be tightly applied. Neither should the collodion be so thin or plentiful that it soaks into and hardens the gauze all round the toe.

The toe is further protected by a quantity of wool bandaged round the whole foot and over the ends of the toes. A square of sponge rubber one inch thick may be strapped under the front of the heel in order to aid walking immediately the operation is over

POST-OPERATIVE CARE AND COMPLICATIONS

The sutches are removed after two weeks, when the arthrodesis is firm. No further splintage should be required, but in a case of doubt a collodion dressing is applied for another two weeks.

Complications

The spike may break during the operation owing to some fault in technique such as clumsy impaction. It may be refashioned farther back, but otherwise arthrodesis has to be abandoned in favour of free resection of the joint.

The spike may disimpact. As a rule this is only discovered after the dressings are removed. It may be possible to review the operation and use the more rigid external fixation of a plaster cast. If stability cannot be attained, free resection is again the last resort.

The circulation in the distal part of the toe may be impaired soon after the operation. Constriction by tight dressings has already been mentioned unsuspected diabetes or peripheral vascular disorders may also give trouble. The dressings must be released immediately

[The illustrations for this Chapter on Spike Arthrodesis for Hammer Toe were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S]

Reference

Higgs, S L. (1931). "Hammer-toe " *Postgrad. med. J.*, 6, 130

CURETTAGE OF A PLANTAR WART

K L Nissen F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Plantar warts of considerable size which have been present for some time, and are painful, are the most suitable for treatment by curettage. Such warts may have failed to respond to simple forms of treatment such as occlusive dressings or the application of a carbon dioxide pencil.

Contra-indications

Multiple tiny warts are unsuitable. Warts which are still moist and sodden from other forms of treatment should be allowed to become again dry and well-defined. No wart showing the slightest invasive tendency after repeated radiotherapy or long-continued applications of strong chemicals should be treated by simple curettage.

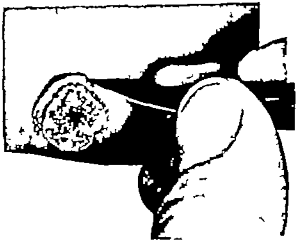
Anaesthesia

A local anaesthetic with the addition of hyalase to aid diffusion may be used, though insertion of the needle into the thick skin of the sole is often painful and the risk of breakage of the needle is considerable For several warts a short general anaesthetic is certainly preferable.

THE OPERATION

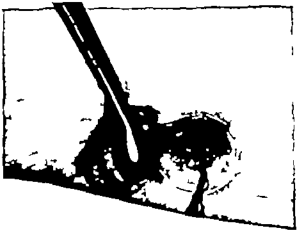
Outlining the wart

1 No tourniquet is required. With a sharp-pointed scalpel held obliquely to the surface of the skin, the wart is outlined two or three millimetres beyond its circular margin. When two or more warts have fused, this outline is arcenate. The point of the scalpel reaches the depressed body of the wart all round below the skin surface but nowhere does it go deep enough to draw blood.



Insertion of curette

2 The edge of a sharp curette is forced into the zone of cleavage between the wart and the surrounding epithelium down to the vascular papillae beneath it.



Removal of wart

3 The wart is levered out of its bed, preferably in one piece. Points of haemorrhage from damaged papillae appear at this stage but the bleeding is easily controlled by firm pressure on the adjacent skin.

Curettage of wart remnants

4 The base of the epithelial defect is repeatedly swabbed and firmly curetted, especially round the edges, till every trace of wart has been removed. On no account should the curette intrude on the subcutaneous tissue.

A small dry dressing is applied and retained for 10 days. The vascular papillae are soon covered with fresh epithelium

Another plantar wart may grow in the same situation this is due either to incomplete curettage or to the growth of an overlooked "seed" wart near by The treatment is a further curettage there is no need ever to excise a simple plantar wart.

[The illustrations for this Chapter on Curettage of a Plantar Wart were prepared by Mr F Price from originals by Mr R J Whitley F R.P.S]

OPERATIONS FOR HALLUX VALGUS AND HALLUX RIGIDUS

K. I. Nissen F.R.C.S

Surgeon, The Royal National Orthopaedic Hospital London

Four straightforward procedures which cover most of the needs of everyday practice have been selected for description—basal osteotomy for inter-phalangeal hallux valgus, simple excision of a painful exostosis, Keller's operation and arthrodesis. A fifth and final operation has been added—amputation of all five toes for the patient with gross hallux valgus and dorsal dislocation of the other toes whose comfort cannot be attained by the use of any kind of surgical footwear

It will be noted that no procedure designed to correct inward deviation of the first metatarsal bone has been selected, nor has any soft tissue technique involving the transplantation of tendons. Keller's operation has been preferred to Mayo's operation for reasons given later (page 800)

Clinical judgment

Three general remarks on the judgment required in the surgery of the great toe may be made. First, no purely cosmetic operation should be lightly embarked on, because comfort may not return to the region and the deformity may progress. Secondly a major reconstruction of the joint can often be avoided by simple excision of a painful exostosis, either the medial exostosis of hallux valgus or the dorsal exostosis of hallux rigidus. Thirdly the decision whether or not to operate should not rest only on the state of the great toe by itself. In particular those important secondary effects of deformity of the great toe—progressive displacement of the second toe in hallux valgus and undue strain on the fourth and fifth metatarsals in hallux rigidus—should always be allowed to influence the decision in favour of operation. On the other hand the rheumatoid state should deter

Time of stay in hospital

In ordinary hospital practice the demand for operations for hallux valgus often exceeds the supply of beds. Methods which reduce the period of stay in hospital are therefore invaluable. The rapid yet efficient handling of patients before and after operation is greatly facilitated by two things—a simplified skin preparation and the careful application of protective dressings. Under favourable circumstances, a simple operation such as excision of a single exostosis requires admission only for one night and can even be done as an out-patient procedure. Many patients who have had a major reconstruction on one side only may proceed home after three or four days.

Skin sterilization

The old method of preparation and towelling thrice repeated is a waste of time and effort. One good wash with soap and hot water followed by one free application of iodine immediately before the operation is enough.

Aids to early walking

A good thickness of protective dressing and some measure to help to keep the toe off the ground are required. A large carpet slipper with the middle half of the sole raised by one or two layers of thick sponge rubber or adhesive felt is very useful the slipper can of course be removed at night.

Anaesthesia

A general anaesthetic is required for each of these five operations.

Tourniquets

An exsanguinating tourniquet is a great advantage in this type of surgery. In younger patients it may be applied round the middle of the calf but for routine use the lower thigh is preferable. The tourniquet is seldom required for more than half an hour and for this reason an Esmarch rubber bandage may be used for both exsanguination and compression of the limb.

Post-operative oedema of the foot

This often prolongs the convalescence. Simple home treatment with hot and cold contrast foot baths and exercises should be commenced a day or two after removal of the stitches, and continued until the foot no longer swells and is again quite supple.

PRE-OPERATIVE

BASAL OSTEOTOMY FOR INTER-PHALANGEAL HALLUX VALGUS

A valgus deformity of the great toe itself occurring mainly in the region of the inter-phalangeal joint is common in adolescent girls. The terminal phalanx deviates under the tip of the second toe towards the tip of the third toe; the whole of the second toe tends to become dorsally displaced. The aims of the operation are not only to straighten the toe but also to prevent the development of deformity at the metatarso-phalangeal joint.

Note.—A similar type of osteotomy permitting elevation of the great toe has a place in the conservative surgery of hallux rigidus.

EXOSTECTOMY

In every case of hallux valgus the head of the first metatarsal is prominent medially. The prominence is usually called an exostosis, though it consists largely of metatarsal head left uncovered by the base of the proximal phalanx.

The pressure of the upper of the shoe often produces a subcutaneous adventitious bursa. Various degrees of bursitis may occur, causing recurrent attacks of pain with redness of the overlying skin or even a purulent effusion leaving a chronic sinus. Sometimes the bursa is distended with glairy fluid like the contents of a ganglion.

Rationale of operation

Removal of the exostosis reduces the width of the forefoot, and the relief of pressure by the shoe allows any inflammatory changes in the bursa gradually to subside. Simple exostectomy does not reduce the outward deviation of the great toe, nor does it relieve pain or stiffness in the metatarso-phalangeal joint.

Note.—A similar procedure may be performed on the head of the fifth metatarsal for a so-called tailor's bunion.

Indications

The most rewarding case is the one of hallux valgus with pain and tenderness over the exostosis, but without displacement of the second toe. When the second toe has already been displaced by the great toe, the prospects of advance of the deformity are greatly increased and the operation is no more than palliative.

Note.—In hallux rigidus without flexion deformity a dorsal exostosis is often the only source of pain and discomfort. The prominence may be either a low transverse ridge of new bone across the metatarsal head or a large prominence which tends to curl over backwards and is often capped with a bursa. Either type may be excised through a longitudinal incision just medial to the extensor tendon.

Contra-indications

Recent acute inflammation of the adventitious bursa is by far the most urgent contra-indication. Ideally the operation should be deferred until 8 weeks after all the inflammation has resolved. When a small sinus with a thin serous discharge persists, however, bed rest before and after the operation, and a wide antibiotic cover, give a reasonable margin of safety.

Diabetes if well controlled is not a contra-indication, but it does call for great care. In older subjects impairment of the peripheral circulation is a common contra-indication otherwise the upper age limit is high.

In rheumatoid arthritis affecting the feet, the operation is often disappointing because deformity of all the toes steadily advances. One good reason for the operation is to simplify the problem of surgical footwear

An exostosis causing no discomfort can be a temptation to operate which demands resistance a painless scar can never be guaranteed.

KELLER S OPERATION

This operation is a simple type of arthroplasty frequently used in cases of both hallux valgus and hallux rigidus. The principal object is to give a painless pseudarthrosis of the first metatarso-phalangeal joint by removal of the base of the proximal phalanx. It is the counterpart of Mayo s operation, in which the same object is attained by removal of the head of the first metatarsal bone. After a Mayo s operation, however pressure is transferred to the heads of the neighbouring second and third metatarsal bones in the course of time this may lead to a painful callosity under the second and third metatarsal heads, thickening and sclerosis of their shafts and sometimes a fatigue fracture. For this reason Keller s operation has largely displaced the Mayo procedure

The alternative to arthroplasty is, of course arthrodesis.

Indications

Keller s operation is used to relieve intractable pain clearly referred to the joint, to restore movement and to correct deformity in cases of advanced disorder

Contra-indications

In young subjects Keller s operation should be delayed as long as possible by various conservative measures. It is seldom justified under the age of 80 years

When the pain is clearly referred to an exostosis, simple removal of the bony prominence may be all that is necessary

In hallux valgus with severe deformity and splaying of the forefoot, Keller s operation is contra-indicated because the shortened and unstable proximal phalanx may dislocate laterally into the wide space between the first and second metatarsal heads.

Other contra-indications such as local sepsis, old age and vascular disorders follow general principles. Active rheumatoid arthritis is an important contra-indication

Special instruments

A sharp hook, a bone-holding forceps, a finger saw and a small bone cutter comprise the special requirements.

ARTHRODESIS OF THE FIRST METATARSO-PHALANGEAL JOINT

The normal range of flexion-extension movement of the first metatarso-phalangeal joint is about 90 degrees, but in walking only a limited range of extension is used. This agrees with the well-known fact that a stiff arthritic joint may be little or no handicap for ordinary activities, provided there is no flexion deformity

The objects of the arthrodesis are to relieve pain, to correct deformity and to improve the function of the foot by fixation of the great toe in a neutral position. The ideal position of the proximal phalanx is in 10-20 degrees of dorsiflexion relative to the shaft of the metatarsal an angle which allows comfort in a walking shoe and which relieves the inter-phalangeal joint of dorsiflexion strain. In addition, a few degrees of outward deviation avoid undue pressure of the upper of the shoe against the inner side of the toe.

As a major reconstructive procedure for routine use, arthrodesis is unlikely to displace Keller s type of simple arthroplasty Technically the operation is more difficult and the after-care is much more prolonged. Arthrodesis counts rather as a useful alternative procedure though on occasions it is without doubt preferable to Keller s operation.

Indications

In hallux valgus with gross deformity arthrodesis is invaluable, because after a Keller's operation the remainder of the proximal phalanx may slip into the wide space between the first and second metatarsal heads.

In hallux rigidus it is the alternative procedure for pain originating in the joint itself and for the correction of a flexion deformity When there is no significant flexion deformity and a dorsal exostosis on the head of the first metatarsal is the source of pain, the exostosis only should be excised and any type of major reconstruction deferred.

When the second toe is relatively long arthrodesis has the advantage that it shortens the great toe by only a small amount this reduces the risk of a hammer toe developing

Because of their sturdy low-heeled footwear men are rather better subjects for the operation than women.

Contra-indications

Certain activities and occupations form contra-indications, for example, the training programme of a fireman who must be able to sprint in rubber shoes. Women who insist on high heels and flimsy footwear are also unsuitable subjects for arthrodesis.

DOUBLE WIRE-LOOP TECHNIQUE

Special Instruments

A small rongeur a bone awl with an eye, stainless steel wire of gauge 27 a small pair of pliers and a wire-cutter are required for this operation.

INLAY BONE GRAFT TECHNIQUE

Special indication

This method is most useful for the occasional case of an unsuccessful Keller's operation, when the shaft of the phalanx is too small for wiring to the metatarsal head.

Special Instruments

A motor saw with a small fine blade is useful for cutting both the graft and the bed for it. Fine chisels from one-eighth inch to one-quarter inch are required for deepening the bed.

AMPUTATION OF ALL FIVE TOES

Indications

In some cases of gross hallux valgus two or three of the other toes may dislocate dorsally Apart from the disorganized joints, pain is often referred to the medial and lateral exostoses, to plantar callosities and to dorsal corns. Such a state of affairs is beyond reconstructive surgery and if the patient cannot be made comfortable in roomy surgical footwear the last resort is amputation of all the toes and remodelling of the metatarsal heads.

Similar deformities may be left when rheumatoid arthritis of the foot has burnt out, with a further possible source of pain in plantar cysts. Other conditions such as advanced pes cavus, contractures from burns, and traumatic dislocations may be associated with deformities of the toes sufficient to warrant this operation.

The aims of the operation are limited. All discomfort from the toes and the joints is certainly eliminated. The plantar callosities, however continue to need attention. As a rule they give less trouble when relieved from the downward thrust of dislocated toes. Because the operation conserves the metatarsal heads a fairly normal walking gait is possible

Contra-indications

Impaired nutrition of the skin and subcutaneous tissues is the main surgical contra-indication. Psoriasis, for example, may cause disorganization of the forefoot very similar to that of late rheumatoid arthritis, but the skin condition precludes operation. The risk of necrosis of the skin flaps increases with advancing years.

An active rheumatoid state in the foot itself is another contra-indication.

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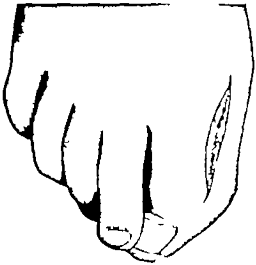
THE OPERATIONS

BASAL OSTEOTOMY FOR INTER PHALANGEAL HALLUX VALGUS

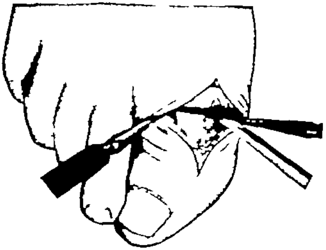
The incision

1 A short straight incision is made medial to the extensor tendon over the length of the proximal phalanx. The junction of the base and shaft is exposed subperiosteally



Osteotomy

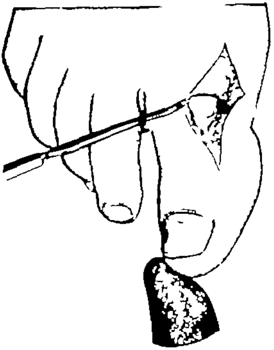
2 Two curved spikes are introduced to protect the long flexor tendon, and a curved osteotomy concave forwards, is made with a narrow thin osteotome.



Straightening the toe

3 The toe is straightened by firm pressure until it can lie comfortably alongside the second toe the stout sheath of periosteum resists over-correction.

When necessary any prominence of the head of the first metatarsal is reduced through the same incision extended backwards. If the extensor tendons to the second toe are taut they are divided subcutaneously with a tenotome.



Closure and fixation

The incision is sutured and a padded below-knee plaster is applied with the great toe held in some apparent over-correction, allowed by the laxity of the neighbouring joint. The great toe is encased in plaster except for the very tip.

For after-care see page 818

EXOSTECTOMY FOR HALLUX VALGUS

Incision and exposure

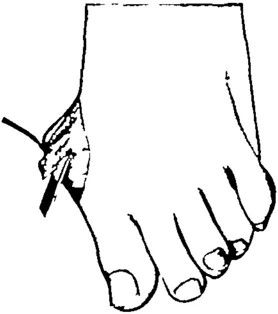
1 *The incision is a slightly curved one over the* prominence well to the medial side of the extensor tendon. With care to avoid any cutaneous nerves, the incision is deepened down to the head and neck of the first metatarsal. A sharp scalpel kept close to the bone is used to elevate in continuity the thick fibrous capsule from the exostosis and the thin periosteum for a short distance proximal to it.

Treatment of the bursa

As far as possible the subcutaneous adventitious bursa is left alone attempts to excise it often damage the overlying skin and may lead to an adherent scar Scarification of the walls of a large bursa is enough to ensure its obliteration.

Excision of the exostosis

2 *The inner side of the joint is now open and the* articular cartilage on the metatarsal head can be inspected. A medial segment will be found to be thin, degenerate and pitted. The cutting edge of an osteotome is placed vertically at the junction with healthy cartilage and driven directly backwards with a hammer The least outward inclination of the osteotome may cause a long sliver of metatarsal shaft to separate. The upper and lower edges of the first cut are trimmed off and all bone particles are carefully removed.

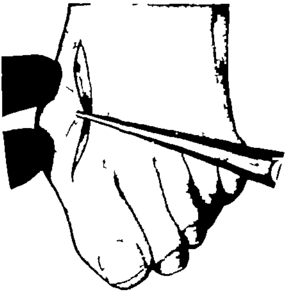


Palpation of the region

3 The skin flaps are replaced and the whole area is carefully palpated through them. It should feel well rounded off. One or more of four bony prominences may however be felt—a ridge remaining on the metatarsal bone, or a fragment of loose bone which has escaped notice, or the base of the proximal phalanx, or the edge of the medial sesamoid.

The first two are easily dealt with. When it is prominent the rim of the base of the phalanx is cleared medially of just enough capsule to allow a thin vertical crescent to be removed with a small bone cutter. Half of the medial sesamoid may also need to be resected.

It is essential that the bone contours should feel perfectly smooth through the skin flaps before the wound is closed.



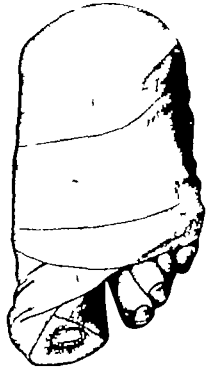
Closure

The incision is sutured, preferably with interrupted mattress sutures, in order to secure some eversion of the skin edges and avoid an adherent scar. The tension of the sutures should be as light as possible otherwise they cut in from the ensuing oedema of the wound edges.

Dressings and bandages

4 Bandaging of the dressings and of the great toe is important. Thick cotton wool is applied all round the foot and ankle, and one piece is put in the first cleft. The wool is bandaged on firmly and the great toe is held in a position of reduced valgus deformity by several figure-of-eight turns. Strips of adhesive tape, 1 inch wide, are applied to secure the bandaging and prevent the great toe from deviating outwards. This improved position of the great toe is maintained for 3 weeks so as to allow the medial joint capsule time to become re-attached well back to the first metatarsal bone.

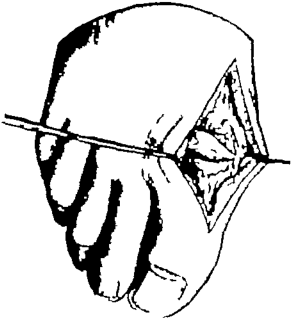
For after-care see page 318



KELLER'S OPERATION

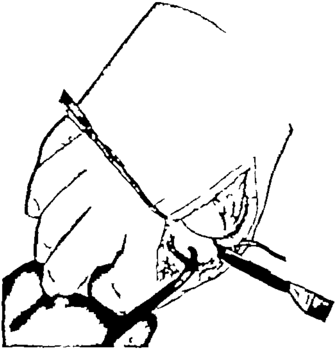
Incision and exposure

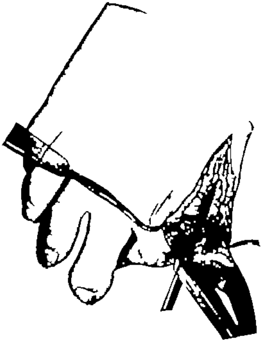
1 A straight incision is made medial to the extensor tendon and deepened down to bone. The head of the metatarsal and the base of the proximal phalanx are cleared of all accessible soft tissues by sharp dissection. During this process the periosteum and the joint capsule are kept as much as possible in continuous layers, suture of which at the end of the operation will provide good deep cover.



Further exposure of the base of the phalanx

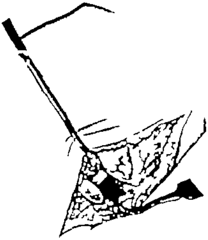
2 The joint is flexed and the end of a sharp hook is forced deeply into the middle of the base of the phalanx. Firm traction on the hook opens out the joint. A sharp scalpel is used to dissect all tendinous structures off the base of the phalanx and down to the middle of the shaft. The contour of the under-surface of the phalanx has to be closely followed, otherwise the flexor tendons may be damaged.





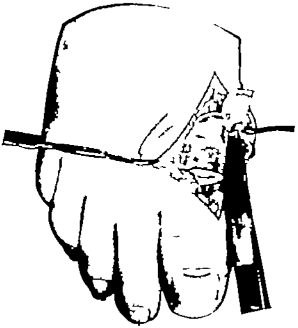
Section of the phalanx

3 The base of the phalanx is securely held in bone forceps. The type here shown in use is specially designed for the purpose. With a finger saw directed away from the vulnerable extensor tendon, the shaft of the proximal phalanx is divided *transversely* just where it starts to expand into the base. Any rough edges of bone are removed with a small bone cutter



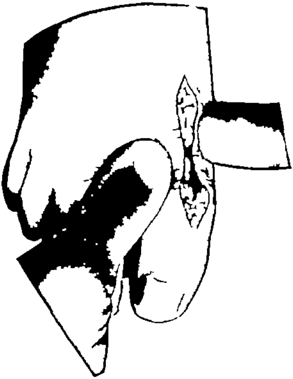
Exposure of flexor sheath

4 The length of the phalanx has now been reduced by about a third and the toe will be shortened by a corresponding amount. When the toe is pulled on a gap appears between the two bon , bottom of which the flexor sheat seen. The sesamoid bones are just o under the metatarsal head. Any bo he gap is wiped out with a gauze s



Trimming of exostosis

5 Any exostosis on the metatarsal head is removed. In hallux rigidus it is dorsal and often curled over backwards. In hallux valgus the exostosis is largely medial the technique of removal has already been described on page 803 This trimming to some extent reduces the inevitable disparity in size between the two bones.



Closure

6 The skin flaps are replaced, the bony contours are palpated and any irregularity is corrected.
There is no need for measures to maintain the gap between the bones either by interposition of soft tissues or by continuous traction on the toe.
The wound is closed in two layers, with fine catgut for the periosteum and joint capsule and interrupted mattress sutures for the skin. Dressings and bandages are applied firmly so that the toe is held in slight dorsiflexion.
For after-care see page 818

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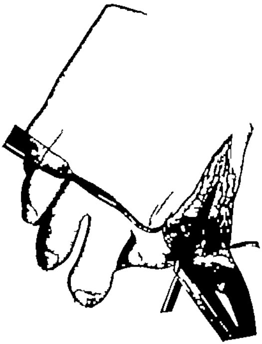

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4 The length of the phalanx has now been reduced by about a third and the toe will be shortened by a corresponding amount. When the toe is pulled on a wide gap appears between the two bones, at the bottom of which the flexor sheath can be seen. The sesamoid bones are just out of sight under the metatarsal head. Any bone dust in the gap is wiped out with a gauze swab.

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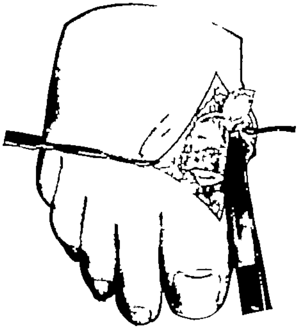

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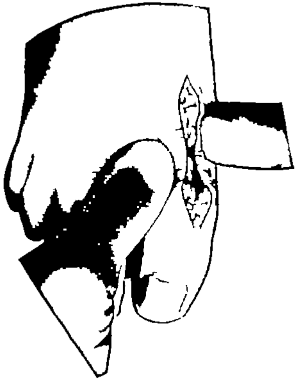


ARTHRODESIS OF THE FIRST METATARSO-PHALANGEAL JOINT

DOUBLE WIRE-LOOP TECHNIQUE

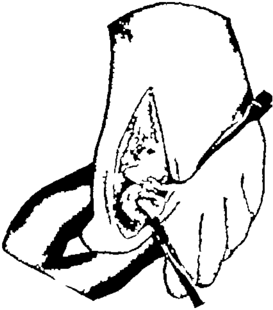
The operation illustrated here follows the technique of Noel Smith and is shown being used for a case of hallux rigidus.

The incision

1 A straight incision is made medial to the extensor tendon and deepened down to bone. The head of the first metatarsal and the base of the proximal phalanx are cleared of soft tissue, the joint capsule and periosteum being kept as far as possible in continuous layers. The joint is flexed fully and free access to all the articular cartilage is obtained.

Excision of the joint

2 The cartilage and a thin layer of subchondral bone are nibbled away from both joint surfaces with a small rongeur which is much more effective than the small osteotome shown here. Enough bone must be removed to expose vascular cancellous bone and to allow free dorsiflexion of the proximal phalanx to between 10 and 20 degrees. The rough convex and concave cancellous surfaces are made as congruous as possible. Any exostosis on the metatarsal head is reduced.



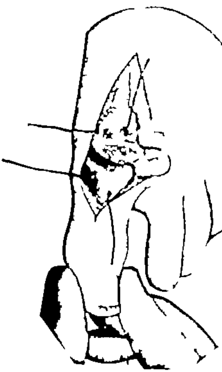
Insertion of the wire loops

3 The awl is now used to drill four holes in the two bones ready for wiring them together with two loops, one in the horizontal, the other in the sagittal plane.

The first pair of holes are drilled transversely one through the base of the phalanx, the other through the metatarsal head.

The third hole runs obliquely downwards and backwards through the base of the phalanx to emerge in the lower part of the joint. The fourth hole, through the metatarsal head, runs downwards and forwards to meet it.

The hole in the end of the awl is made use of to introduce a length of stainless steel wire, gauge 27 into each pair of holes so that the ends come out on the medial and dorsal aspects respectively

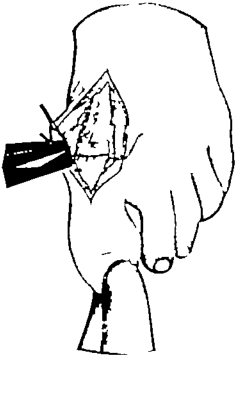


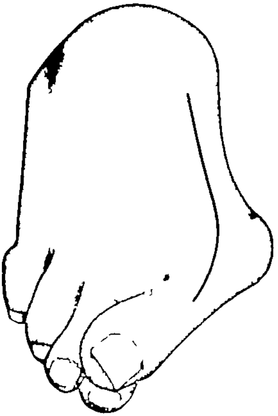
Tightening of the loops

4 The proximal phalanx is held in a position of 10–20 degrees of dorsiflexion, a few degrees of outward deviation and as little rotation as possible. The unseen slack in the wire is firmly pulled out of each loop in turn with a pair of pliers and the wires are carefully twisted tight over the former joint line. The wire most liable to cut out with over-tightening is the proximal side of each transverse loop because it often emerges through cancellous bone left after trimming of an exostosis. The twisted ends are cut short and pushed out of harm's way into the line of the excised joint. Any minor adjustment of position is now made.

Closure and protection

The subcutaneous tissues are approximated with fine catgut and the skin is closed with mattress sutures so as to avoid an adherent scar. Plenty of cotton wool is bandaged all round the foot and ankle and a few turns of plaster of Paris bandage are applied to form a thin protective shell, particularly over the great toe itself.





INLAY BONE GRAFTING TECHNIQUE

This alternative method is here shown being employed for a case of severe hallux valgus.

Incision and excision of joint

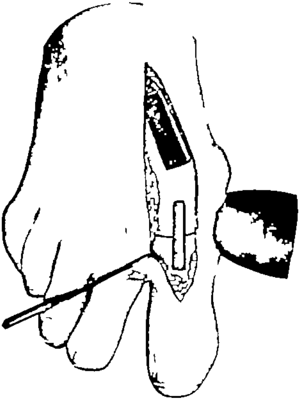
1 The joint is excised in the same way as for wire-loop arthrodesis but the incision is extended up the whole length of the shaft of the first metatarsal. The base of the proximal phalanx is freely exposed laterally so as to elevate the insertion of the adductor transversus and permit correction of the principal deformity

Cutting and insertion of graft

2 Two parallel cuts one inch long and three-eighths of an inch apart are made in the shaft of the first metatarsal with a motor saw The saw is made to run slowly and the blade is cooled with cold saline solution delivered at a safe distance from a large syringe fitted with a medium sized needle. In this operation on small bones special care must be taken to keep the assistant s fingers out of the way

The ends of the parallel cuts are joined by using a narrow chisel, and the graft consisting of cortical bone with cancellous bone attached to its deep surface is carefully elevated.

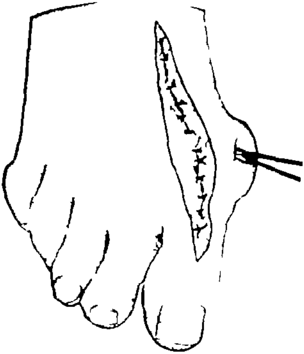
The toe is held in the corrected position and two parallel cuts one inch long and one-eighth of an inch apart are made deeply across the joint with a saw The bed is further prepared with narrow chisels and the graft is slotted firmly home



Closure and fixation

3 The wound is closed as usual in two layers. No attempt is made to deal with the bursa, which gradually disappears leaving a better contour of the region.

An inlay graft gives less stability than double wire loops. For this reason careful fixation in plaster of Paris has to be used from the beginning. Otherwise the after-care is similar



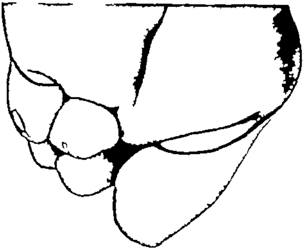
AMPUTATION OF ALL FIVE TOES

The incision

1 A single transverse incision is used. It begins and ends as two narrow rackets over the first and the fifth metatarsal heads. The incision extends for a short distance down on to each proximal phalanx (see dotted line)

The incision completed

2 The plantar excision similarly extends down on to each toe. It almost meets the dorsal incision in each web space. In this way an adequate amount of skin is retained in order to give good cover without tension. The incision is deepened down to bone, the flexor and extensor tendons being divided transversely in the process.



Disarticulation

3 Each toe is disarticulated in turn. All five toes may in this way be removed in a row connected by thin strips of skin from the web spaces.

The skin flaps are replaced and the bony contours of the metatarsal heads are palpated. Any undue prominence is freely reduced, whether it is medial, lateral or plantar. The sesamoids may need to be excised.

Treatment of the soft tissues

In cases of rheumatoid arthritis the soft tissues underneath the metatarsal heads are carefully inspected and any adventitious cysts are removed. These may be found originating either from a flexor tendon sheath or from an intermetatarso-phalangeal bursa or from the subcutaneous tissue itself.

The plantar digital nerves are left long so that each terminal neuroma will be well forward of the weight-bearing area. If any tendon fails to retract within its sheath it is cut back.

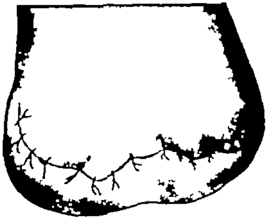
Control of haemorrhage

The tourniquet is released and haemorrhage controlled by pressure on a towel soaked in hot saline. It is seldom necessary to tie any blood vessel.

Closure

4 The irregular skin flaps are approximated loosely. There is sometimes an excess of skin in the plantar flap which requires local excision.

For after-care *see* page 814



POST-OPERATIVE CARE AND COMPLICATIONS

BASAL OSTEOTOMY FOR INTER-PHALANGEAL HALLUX VALGUS

Radiographs are taken to check the position. After 2 weeks a below-knee walking plaster is applied over stockinet with the great toe now in correct alignment. Again the great toe is almost completely enclosed, with the other toes left free The cast is retained for a further 6 weeks, when radiographs confirm bony union

Broad shoes with straight inner borders are recommended. A hallux valgus night splint may be prescribed as an extra precaution against incipient deformity at the metatarso-phalangeal joint.

EXOSTECTOMY

The after-care varies according to circumstances. In a straightforward case the patient is allowed to walk the next day with the aid of appropriate measures to keep the great toe off the ground.

Complications

Septic infection may involve the joint in such a case it is important to maintain the toe in a position of slight dorsiflexion in case ankylosis occurs. Persistent local tenderness of the area may be due either to a spicule of bone or to a neuroma on a cutaneous nerve in either case the surgical treatment is simple.

KELLER S OPERATION

The toe is allowed to rest in the corrected position for 2 weeks, when the stitches are removed. The patient is then *encouraged to perform active and gentle passive movements, mainly in the direction of dorsiflexion.* The pseudarthrosis may take a month or more to acquire a useful range of painless movement.

Complications

Apart from the improper selection of cases, there are two common sources of error When too little bone has been removed the end-result may be a painful fibrous ankylosis the treatment is arthrodesis. When too much bone has been resected, the joint is flail, the toe is very short and the cosmetic result is poor Fortunately the lax joint is seldom painful.

ARTHRODESIS OF THE FIRST METATARSO-PHALANGEAL JOINT

After 2 weeks a below-knee walking plaster is applied with the great toe almost completely encased the other toes are left free. The cast is removed after 2 months, when radiographs are taken to confirm bony union.

Appropriate shoes with heels of a moderate height are advised any alteration such as a metatarsal bar is seldom required.

DOUBLE WIRE-LOOP TECHNIQUE

Complications

Non-union is rare The usual causes are failure to remove enough sclerosed bone and inefficient tightening of the wire loops. If the fibrous ankylosis is in good position no further treatment may be needed otherwise the treatment is arthrodesis with the aid of a bone graft. Sound union may occur but in a degree of flexion sufficient to cause undue strain on the inter-phalangeal joint. A dorsal wedge osteotomy of the base of the proximal phalanx may then be required to give an attitude of 10–20 degrees of dorsiflexion.

INLAY BONE GRAFT TECHNIQUE

Complications

The metatarsal bone may fracture through the donor site some time after the patient has been walking normally A further period in a walking plaster is required.

AMPUTATION OF ALL FIVE TOES

Stitches are removed after a fortnight and weight-bearing in soft slippers can commence soon afterwards. It then remains to supply appropriate footwear If the rest of the foot is normal in shape all that may be required is a soft sponge-rubber metatarsal pad to support the metatarsal heads, and blocking in of the empty toe-cap When the remainder of the foot is deformed, however a surgical shoe again with a deep sponge-rubber insole, is required.

Complications

When the nutrition of the region is impaired or when there has been undue tension on the skin stitches local necrosis of the skin flaps may occur

The relative alignment of the metatarsal heads may alter after removal of the downward pressure exerted by the deformed toes. For this reason further remodelling of the plantar surface of a metatarsal head may be required after an interval of time. In cases of late rheumatoid arthritis a fresh cystic formation may develop in the sole and require to be removed.

[*The illustrations for this Chapter on Operations for Hallux Valgus and Hallux Rigidus were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S*]

REMODELLING OF THE POSTERIOR TUBEROSITY OF THE CALCANEUM

K. I. NISSEN F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

The profile of the back of the calcaneum is usually rounded, but when it is steep and prominent, pressure from the boot or shoe may cause a subcutaneous bursa to develop over the tendo Achillis just above its insertion. The bursa and the thickened tissues around it often become painful and tender especially in winter when a heavier type of footwear is worn and when the foot is subject to chilblains. Hence the colloquial term "winter heel" Most of the patients are adolescent girls or young women.

The symptoms can often be controlled by making the upper of the shoe soft in that region. Excision of the adventitious bursa is quite useless—the prominent bone remains exactly as before. Permanent relief can be given only by removing all the postero-superior margin of the calcaneum above the insertion of the tendo Achillis.

Anaesthesia and position of patient

A general anaesthetic is given an exsanguinating tourniquet is applied up to the lower thigh and the patient is placed in the lateral position.

THE OPERATION

The incision

1 A lateral incision about 8 inches long is made just forward of the anterior margin of the tendo Achillis down to the lateral surface of the calcaneum. The operation demands free access the temptation to use a short horizontal incision following a skin crease should be resisted.

The anterior surface of the tendon is defined and followed downwards until the bursa normally present between the tendon and the upper third of the posterior tuberosity is entered. This deep bursa appears perfectly normal—the symptoms arise entirely from the adventitious bursa which of course is superficial to the tendon and is left undisturbed by the operation. (Inflammation of the deep bursa does occur but rarely and with a normal profile of the calcaneum the treatment is resection of bone in the same way.)

Exposure and section of bone

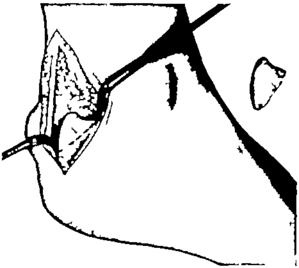
2 Full access to the insertion of the tendon is now obtained from above by placing the foot in equinus and holding the slack tendon back from the calcaneum with a narrow Langenbeck retractor

The tendon is very carefully disinserted for a quarter of an inch (0 5 cm.) with a scalpel kept close to the bone.

The upper surface of the calcaneum is next exposed extraperiosteally for a distance of about an inch (2 5 cm.)

The tendon is again retracted and the prominent margin of the bone is excised in one piece with an osteotome. The direction of the osteotome is strictly transverse the plane of the blade is 45 degrees obliquely forwards. One edge of the osteotome is of course close to the reflected part of the tendon, which is at risk unless it is held clear

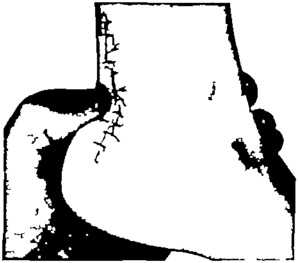
The edges of the cut bone are rounded off, especially over the narrow transverse area from which the tendon was elevated.



Closure

3 The skin flaps are replaced and the new bone contours carefully palpated for any irregularity before the wound is finally sutured.

The whole of the foot and ankle region is covered with cotton wool and a firm domette bandage.



POST-OPERATIVE CARE AND COMPLICATIONS

Two squares of sponge rubber one inch thick are fixed under the front of the heel with adhesive bandage. This allows the patient to walk after two or three days with the foot in some equinus and the tendo Achillis relaxed. If by mischance the tendon has been lacerated, a below-knee plaster cast is applied instead with the foot in equinus.

The stitches are removed after a fortnight. Vigorous games are not allowed for 2 months.

Complications

Discomfort may continue. The common reason for this is inadequate resection of bone which in turn is commonly caused by inadequate access. The treatment is free resection as shown.

Rupture of the tendo Achillis has been reported. This can occur either from negligence during the operation or from the resumption of athletic activities too soon afterwards.

[The Illustrations for this Chapter on Remodelling of the Posterior Tuberosity of the Calcaneum were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S]

EXCISION OF THE HEAD OF A METATARSAL BONE

K. I. Nissen F.R.C.S.

Surgeon, The Royal National Orthopaedic Hospital London

Indications

The term excision of a metatarsal head here refers to the second, third and fourth metatarsals. It is really a type of simple arthroplasty corresponding with a Mayo s operation. The common reasons for removal of a single metatarsal head are secondary arthritis of the joint, usually the late sequel of osteochondritis, or dorsal subluxation or dislocation of the proximal phalanx.

In a case of old-standing osteochondritis the metatarsal head is enlarged and the joint is rigid. Excision of the head serves to remove all the osteophytes and in addition any loose body which has separated from the dorsal aspect of the head.

Dorsal subluxation or dislocation of a single joint, usually the second or third, may be spontaneous and may occur without any other defect in the architecture of the forefoot. Frequently however it affects the second joint as a complication either of a hammer toe, or of advanced hallux valgus deformity causing dorsal displacement of the whole of the digit. Whatever the aetiology a callosity develops under the metatarsal head, and the radiograph shows widening and sclerosis of the metatarsal shaft as another indication that the metatarsal head is taking more than its share of body weight. The localized callosity always occurs directly under the downward bony prominence and fades out into normal skin. This helps to distinguish it from a plantar wart with its rounded outline and definite black spots of included debris.

When a hammer toe is dorsally dislocated, excision of the metatarsal head takes precedence over any measure for straightening of the toe such as spike arthrodesis otherwise the toe lies well above the level of its neighbours and the dislocated joint continues to give trouble.

When hallux valgus requires correction, excision of the second metatarsal head allows the second toe to take up a lower position and so to give the great toe a measure of lateral support.

In the common case of anterior flat foot, however all three metatarsal heads are depressed. There is often no demonstrable subluxation. The local pain and tenderness are referred directly to the wide callosity and there is seldom any radiation of pain to the toes (compare Morton s metatarsalgia)

Many of the conditions mentioned above can be relieved by simple measures such as sponge-rubber metatarsal support, paring of the callosity and so on. Intractable local pain and tenderness are the symptoms which determine operation. When only one joint is disordered, only that metatarsal head need be resected. In a case of generalized flat foot, however the question is one of numbers—whether to excise one, two or even three metatarsal heads at the one sitting. One alone often proves to be not enough and the next head has to be excised at a later date Some surgeons boldly excise all three metatarsal heads.

Contra-indications

The operation should be avoided during the period of growth. In cases of advanced rheumatoid arthritis or gross hallux valgus with dorsal dislocation of several joints, the operation is frequently disappointing it may in fact only accelerate the disorganization of the forefoot. If surgical footwear fails to relieve the pain and discomfort, amputation of all five toes may be indicated.

At one time excision of the fourth or fifth metatarsal head was performed for the relief of Morton s metatarsalgia, but this operation has been abandoned since the discovery of the characteristic nerve lesion.

A plantar wart modified by pressure and perhaps by chiropody should not be mistaken for a painful callosity

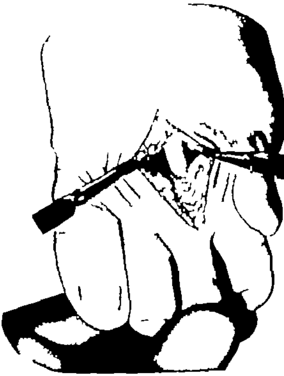
Special Instruments

A pair of small bone spikes or curved dissectors and a small bone cutter are required.

THE OPERATION

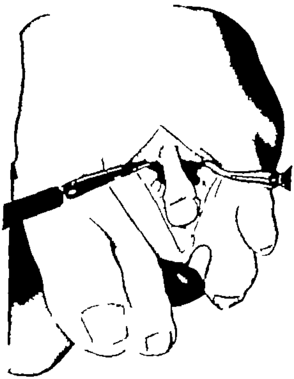
The Incision

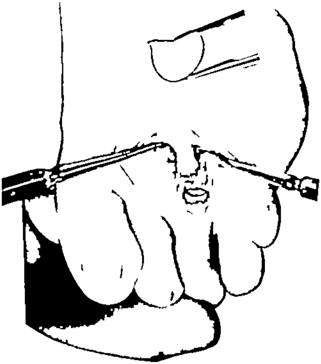
1 A straight dorsal incision is made over the distal half of the metatarsal and base of the proximal phalanx. Two metatarsals may be dealt with through a single incision placed between them. The extensor tendons are retracted to one side. The neck of the metatarsal is exposed extra-periosteally and curved spikes or dissectors are passed beneath it in order to protect the flexor tendons.



Dorsal dislocation of the metatarsal head

2 The joint is entered and the metatarsal head is cleared of all soft tissue especially the stout lateral ligaments. Strong traction on the toe in full flexion causes the head to dislocate into the wound.





3 **Resection of the head**

The head is removed completely with a small bone cutter Care is taken not to leave any spike of bone projecting downwards against the flexor tendon sheath The neck of the metatarsal is well rounded off and, after a search for any loose fragment of bone, it is returned to its former position The wound is sutured without drainage

ALTERNATIVE PROCEDURE

Basal osteotomy of the affected metatarsals permitting elevation of the depressed heads can also be performed, but the after-care is more prolonged.

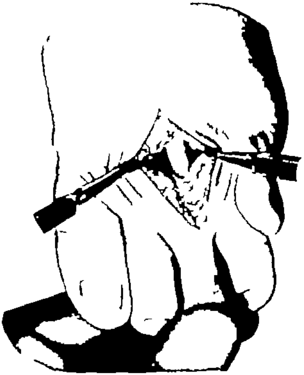
POST-OPERATIVE CARE

Weight-bearing on the forefoot is not allowed until two weeks from the operation. At this stage a soft sponge-rubber metatarsal support is useful it hastens the disappearance of the tender callosity It is good practice to have the insole supplied and worn for a few weeks *before* the operation.

Complications

Continued pain may be due to a spike of bone projecting downwards following incomplete resection of the metatarsal head. It can be shown in a tangential radiograph.

[The illustrations for this Chapter on Excision of the Head of a Metatarsal Bone were prepared by Mr F Price from originals by Mr R J Whitley F R.P S]



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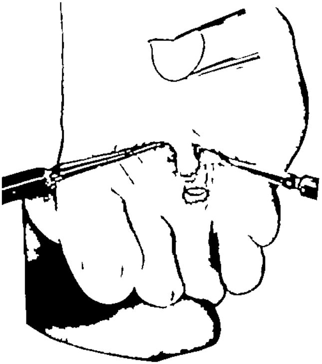

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[The illustrations for this Chapter on Excision of the Head of a Metatarsal Bone were prepared by Mr F Price from originals by Mr R J Whitley F R P S]

MORTON'S METATARSALGIA
RESECTION OF A PLANTAR DIGITAL NERVE

K. I. Nissen, F.R.C.S.

Surgeon, The Royal National Orthopaedic Hospital, London

PRE-OPERATIVE

In Morton's metatarsalgia acute neuralgic pain is felt in the sole of the foot in the region of the third and fourth metatarsal heads. The pain often radiates to the third and fourth toes and sometimes to the second; it may even be confined to one toe, usually the fourth (Morton's toe). The pain comes on with walking or long standing and is relieved by taking off the shoe and by rest. Most of the patients are women.

The source of the pain is a characteristic fusiform "neuroma" at the point of division of a plantar digital nerve, usually in the 3–4 space, sometimes in the 2–3 space, occasionally in both. The nerves in the 1–2 and 4–5 spaces are not affected by this typical lesion. The term "neuroma" is really incorrect, because the nerve lesion is degenerative and ischaemic in nature.

The foot usually appears to be perfectly normal. The proliferated connective tissues which comprise the bulk of the swelling are soft in consistency and can seldom if ever be clearly palpated.

There is, however, *one cardinal sign*—acute tenderness on firm backward pressure in the web space over the point of division of the nerve. Impressive clicks may often be felt in the web spaces with intermittent compression of the forefoot (Mulder's clicks), but in the absence of this focal tenderness they have little significance.

Indications

When no other cause has been found for the pain, and if it is giving enough trouble, exploration of the tender web space or spaces is indicated.

Now and again operation is indicated in the absence of pain for a patient who is forced either to restrict walking to a short distance or to wear light, open footwear such as sandals or slippers all the year round in order to obtain comfort.

Contra-indications

Rheumatoid arthritis, or any suggestion of it such as a raised sedimentation rate, is an absolute contra-indication.

Pain felt immediately on standing is seldom due to true Morton's metatarsalgia, likewise pain at rest. Local oedema, colour changes or joint stiffness all weigh heavily against this diagnosis.

Anterior flat foot is certainly not a contra-indication; when a neuroma is present the point of focal tenderness is of course well forward of the plantar callosity.

Anaesthesia and position of patient

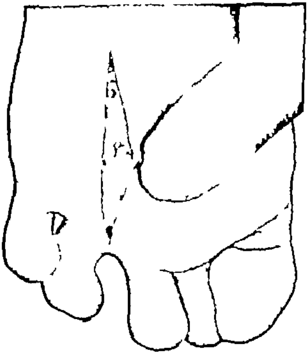
A general anaesthetic is given and an exsanguinating tourniquet is applied up to the lower thigh. The patient lies prone with the foot over the end of the table.

THE OPERATION

The Incision

1 The metatarsal heads on either side of the suspect interspace are palpated and a straight incision about 2 inches long is made between them right across the weight-bearing area and down to the web space For preference the incision should not encroach on the non-weight-bearing part of the sole because this *part of a long scar often stays thickened* and tender for some time.

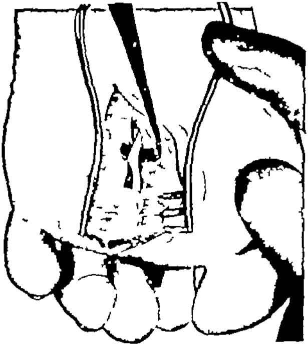
In the operation illustrated here the incision is slightly longer and the access considerably greater than usually required. The source of pain may even prove to be a cyst, not a neuroma.



Identification of the plantar digital nerve

2 A self-retaining retractor is inserted. The proximal part of the wound is deepened and the slender digital nerve is found midway between the two flexor tendon sheaths.

If the diagnosis were always correct the operation could end at this point with high division of the nerve the inevitable terminal neuroma would then be free from pressure and quite painless. The percentage of diagnostic error however is considerable and an adequate lesion should therefore be demonstrated.



Exposure of the lesion

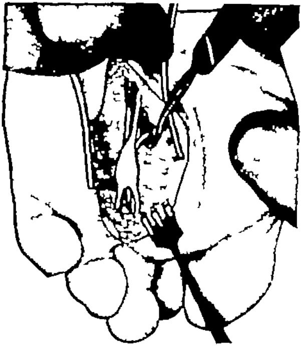
3 The nerve is traced downwards and the neuroma is found at the level where it divides to supply the adjacent sides of the toes. The branches to the toes issue from the distal part of the swelling

The local surgical anatomy.—The digital nerve lies in a shallow trough, the sides of which are the flexor tendon sheaths and the floor is the transverse metatarsal ligament. The nerve is well protected from pressure on the sole. The plantar digital artery enters the field of operation through small foramen just above the ligament. It approaches the neuroma obliquely and adheres both to its deep surface and to the transverse ligament. The communicating artery from the dorsum lies between the two branches of the nerve. The lumbrical muscle is easily recognized its tendon is very thin and is often adherent to the transverse ligament.

Special cases

(1) When a double lesion is suspected the 3–4 space is explored first. Medial retraction of the wound permits exploration of the 2–3 space as well.

(2) When a neuroma cannot be demonstrated, a careful search is made for other lesions. The most likely ones are cystic formations arising either from a flexor tendon sheath or from the inter-metatarso-phalangeal bursa. In a difficult case both interspaces are examined.

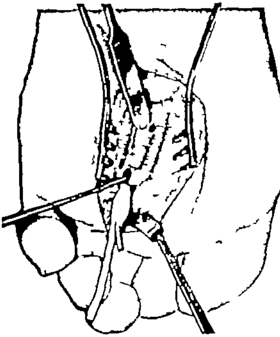


Resection of the nerve

4 The digital nerve is divided high up under the plantar fascia well away from the weight bearing area and 3–4 cm. above the neuroma. This high division may be regarded as the prophylactic treatment of a painful terminal neuroma. The digital vessels are also divided they are sclerosed and contain little blood.

The nerve is turned downwards and the neuroma, which now includes the vessels, is found to be adherent to the transverse ligament. Beyond the ligament it is again adherent to the distal wall of the inter-metatarso-phalangeal bursa which generally comes away with the specimen. The narrow cavity of the bursa extends backwards deep to the transverse ligament. The specimen is freed by division of the branches to each toe

NOTE.—When normal, the vessels and nerve are of even calibre and are not adherent, either to one another or to the transverse ligament, or to the bursa.



Closure and dressings

When a typical lesion has been found drainage is unnecessary Dry dressings are applied and plenty of cotton wool is bandaged round the foot and ankle

ALTERNATIVE TECHNIQUE

The use of a dorsal incision —The point of division of a plantar digital nerve is readily accessible in the web space. For this reason many surgeons, particularly in America use a short dorsal incision into the web and resect the affected segment with very little of the nerve trunk above it. When the diagnosis is correct this minor procedure does relieve the pain, but it has two disadvantages. First, limited resection of the nerve often leads to recurrence of pain from pressure on a terminal neuroma. Secondly any other lesion in the sole simulating Morton s metatarsalgia, especially a cyst on the flexor tendon sheath, may not be discovered. For these reasons the access given by the plantar incision originally used by Betts is preferable

Procedures other than that of resecting the plantar digital nerve are sometimes advocated

(1) Resection of a metatarsal head this has been abandoned since the discovery of the characteristic nerve lesion

(2) Amputation of a Morton s toe this gives no relief.

(3) Manipulation of the foot this may give temporary relief, but its main value is to exclude minor and reversible stiffness of the forefoot as a source of pain. For example it should always be performed when there is a history of immobilization of the foot in plaster prior to the onset of symptoms.

POST-OPERATIVE CARE AND COMPLICATIONS

The patient is allowed to take weight on the heel the day following operation, but pressure on the forefoot is avoided until the stitches are removed after 14 days.

The wound heals soundly and after a period of full weight-bearing the scar is only just visible. The adjacent skin sometimes stays sensitive to light stimuli.

Complications

A deep haematoma may develop and become infected. This is due to failure to drain the wound. When any cystic structure has been found or when an apparently normal nerve with normal blood vessels has been resected.

Pain of a similar type sometimes recurs after an apparently successful operation. There are three common causes first, another lesion in the adjacent interspace secondly a painful adherent terminal neuroma resulting from inadequate resection of the nerve and thirdly some variety of cyst. Any such lesion may of course demand further exploration of the sole.

[*The illustrations for this Chapter on Morton s Metatarsalgia were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S*]

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ELONGATION OF THE TENDO ACHILLIS

K. L. NISSEN F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

This and the chapters Soft Tissue Correction of a Club Foot Multiple Osteotomy for Metatarsus Varus and Rotation Osteotomy of the Tibia are operations usually carried out for the treatment of a relapsed club foot

SUBCUTANEOUS TENOTOMY

Indications

Subcutaneous tenotomy for correction of the equinus deformity of congenital club foot was introduced before the era of anaesthetics and antiseptic surgery The operation has long since been abandoned in children

This procedure is a useful quick operation in poor risk patients, particularly adults with severe spastic equinus of the foot from cerebral thrombosis, disseminated sclerosis traumatic hemiplegia and so on, when the drop-foot cannot be controlled by toe-raising apparatus or when such apparatus is too heavy and cumbersome.

When the foot is also held inverted, open division of the tendon of tibialis posticus through a short incision near its insertion may be performed at the same time. This combination of these two minor procedures is often highly successful in the control of spastic equino-varus in adults, and takes only a few minutes to perform.

Complete transverse division of the tendo Achillis is sometimes performed for the relief of pain in intermittent claudication the effect is equivalent to paralysis of the calf muscle.

Contra-indications

The tendon and the skin overlying it should be sound. Should the tendon feel nodular a radiograph may reveal patches of calcification the risk of complete rupture at operation is then high.

In young and healthy subjects the subcutaneous operation is not employed because too much or too little lengthening may result, and there is always some risk of division of the tendon being complete or nearly so

Anaesthesia

A general anaesthetic of short duration is required. Muscle relaxants are contra-indicated for the reason that if the calf muscle lacks all tone the tendon may fail to elongate when the foot is dorsiflexed.

Position of the patient

The patient lies prone with the foot and ankle over the end of the table. A tourniquet is superfluous.

OPEN ELONGATION

Open elongation is superior to the subcutaneous or closed operation under most circumstances, because the amount of lengthening can be gauged exactly and there is no risk of undue narrowing of any part of the tendon.

The operation leaves the calf muscle intact. For this reason there is less risk of the slow development of a secondary calcaneus deformity from weakness of the calf muscle some years after a Stoffel s neurectomy

Indications

The general indication for operation is equinus deformity of the foot which resists conservative measures such as corrective plaster casts for a club foot or toe-raising apparatus in a case of spastic paralysis.

One variety of mobile pes plano-valgus is secondary to tautness of the tendo Achillis and moderate lengthening of the tendon is essential in order to control the everted attitude of the heel.

Contra-indications

When the equinus deformity is actually an advantage, for example when the limb is short, or when control of the knee is impaired by weakness of the quadriceps, elongation of the tendo Achillis may only increase the disability. Here are two reasons why elongation of the tendo Achillis has a limited use in the reconstructive surgery of anterior poliomyelitis.

In cerebral palsy (Little's disease) affecting young children the operation should be deferred as long as possible—for months or even years—in order to provide every opportunity for spontaneous improvement of the foot during walking. Because the spasm of the calf muscle relaxes during sleep there is little risk of delay in operating leading to any serious degree of fixed equinus.

A congenital club foot in an older child may not respond to the operation because the ankle mortise has become too narrow for the anterior part of the articular surface of the talus; in such cases correction may have to wait till an operation on bone, such as a modified Lambrinudi drop-foot operation, can be performed.

Anaesthesia

A light general anaesthetic is required and an exsanguinating tourniquet is applied to the lower thigh. No muscle relaxant should be given before the tourniquet is in position because normal tone in the calf muscle is required at the stage of correction.

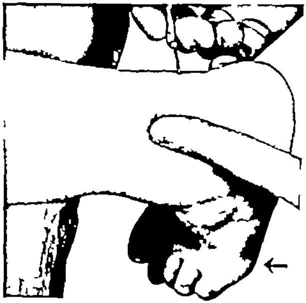
THE OPERATIONS

SUBCUTANEOUS TENOTOMY

Hemisection of the tendon

1 Pressure is applied to the ball of the foot so as to make the tendo Achillis taut. The surgeon defines the lower part of the tendon and selects a point in the middle of the tendon about half an inch above the calcaneum, that is at a level clear of pressure from the upper of the shoe.

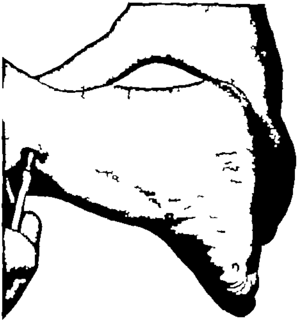
The blade of a tenotome is introduced on the flat deep to the tendon and then turned towards the surface. Half of the tendon and no more is divided transversely; a few drops of blood appear at the site of puncture.



Hemisection at a higher level

2 The procedure is repeated in the reverse direction about two inches higher up. The greater the amount of equinus to be corrected, the greater must be the distance between the two levels of hemisection in order to avoid complete rupture of the tendon.

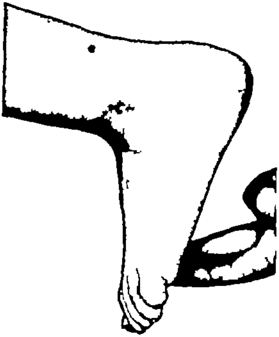
In some adult patients the landmarks are obscured by a thick layer of subcutaneous fatty tissue. The point of the tenotome must then be used first to determine the edge of the tendon. Again no more than a few drops of blood should appear.



Forced dorsiflexion of the foot

3 Powerful dorsiflexion strain is now applied to the foot in order to make the longitudinal fibres down the middle of the tendon give way between the ends of the two cuts. The first attempt may be unsuccessful, in which case a few more fibres are divided at the upper end.

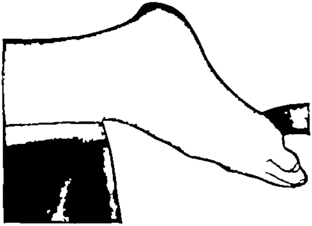
When the tendon does start to stretch, there is an immediate change in its contour and the overlying skin becomes taut. The foot is pushed well up into dorsiflexion, perhaps 20 degrees above the right angle, with the knee extended. In cases of old-standing deformity the tendon may fail to elongate because the ankle joint may resist dorsiflexion. The patient is turned into the supine position and a lightly-padded below-knee plaster cast is applied, with the foot as a rule in the neutral position.



OPEN ELONGATION

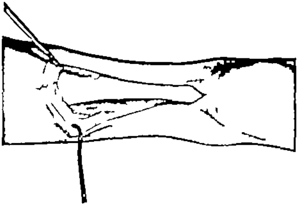
Position of the patient

4 The patient lies almost prone with the foot and ankle over the end of the table. This position is ideal for the application of applied dorsiflexion force.



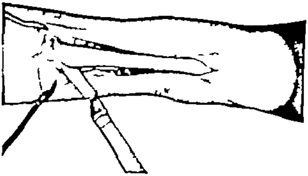
The incision

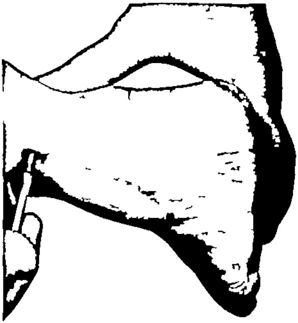
5 The incision is a straight vertical one down the middle of the tendon 3 or 4 inches long
A straight incision has the cosmetic advantage over a curved incision in that in women the fine scar is concealed by the seam of the stocking
The glistening superficial surface and sides of the tendon are freely exposed. There is no need to conserve the tenuous "sheath" but care should be taken not to disturb the soft tissues attached to the deep surface of the tendon.



Division of the tendon

6 The tendon is kept taut by firm pressure under the forefoot. A sharp broad scalpel is introduced in the coronal plane about one inch above the calcaneum and the middle half of the tendon is divided into two layers of equal thickness. The scalpel is then made to come out gradually to the surface of the tendon at a point short of the muscle fibres.





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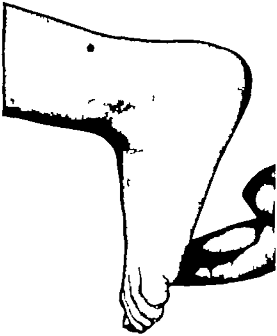

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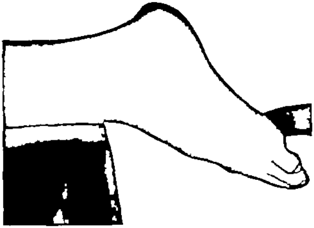

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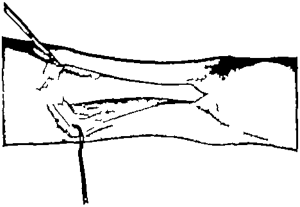

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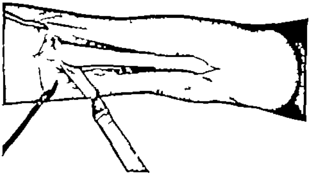
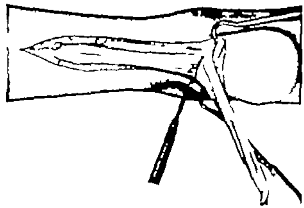


Division of the tendon completed

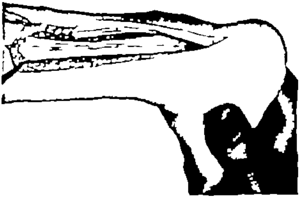
7 The superficial strip of tendon is held out of the way. With the scalpel reversed in direction the deep half is gradually divided towards the calcaneum and incidentally towards the back of the ankle joint. The soft tissues deep to the tendon are again left undisturbed.



Elongation of the tendon

8 With controlled dorsiflexion strain, elongation of the tendon occurs by movement distally of the layer attached to the calcaneum. As a rule the surgeon is not content till the foot has been pushed up into some calcaneus with the knee straight.

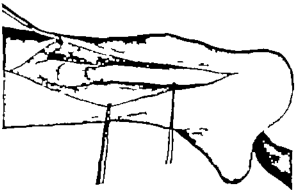
In cases which resist correction, posterior capsulotomy of the ankle joint may be performed between the lowest fibres of flexor hallucis longus and the peroneal tendons. Opinions differ on the merits of this procedure; some surgeons consider it to be most effective.



Suture of the tendon

9 The foot is kept in the fully corrected position and the cut surfaces of the two layers of tendon are simply approximated at four points by fine black silk. The knots are arranged away from the superficial surface in order to keep it smooth. With this technique more sutures are unnecessary because the proximal layer of tendon is well held by the undisturbed soft tissues deep to it and because the tension of the skin flaps holds the two layers in apposition.

The contours of the tendon are hardly changed. This is one advantage over division of the tendon by the long Z-shaped cut made in the sagittal plane so commonly shown in diagrams of this operation.



Closure

For ease of suturing of the skin the foot is allowed to relax temporarily into slight equinus. Some mattress sutures are used in order to avoid inversion of the skin edges and an adherent scar.

POST-OPERATIVE CARE AND COMPLICATIONS

SUBCUTANEOUS TENOTOMY

Whenever possible the patient is allowed up on the day following the operation. Most of the subjects for subcutaneous tenotomy come into the category of "medical spastics" and they lose ground when confined to bed. In order to allow partial weight-bearing a square of sponge rubber one inch thick may be strapped under the front of the heel of the plaster cast.

A standard below-knee walking plaster is applied after a fortnight and retained for a further 4 weeks.

Complications

Complete division of the tendon is simply an error of judgment.

In cases of old-standing deformity the tendon may fail to elongate because the ankle joint may resist dorsiflexion.

Calcified nodules sometimes develop at the site of elongation they should not matter in the type of patient selected for this blind procedure.

OPEN ELONGATION

Immediately after the operation dressings are applied and the patient is turned into the supine position for the application of a lightly-padded below-knee plaster holding the foot as a rule in a few degrees of calcaneus. In resistant cases too much corrective pressure beneath the forefoot is to be avoided because of the risk of ulceration of the sole.

After 2 weeks a standard below-knee walking plaster is applied and is retained for a further 4 weeks.

Complications

Post-operative complications are few Knots of suture material sometimes require to be removed, particularly when too large a number have been inserted.

The equinus deformity may gradually recur from continued muscle imbalance, but a second elongation is rarely necessary Calcified deposits in the tendon are most unusual, probably because of the close apposition of the two flat segments of tendon.

The vertical midline scar fades well and is almost invisible through a silk stocking because it lies under the seam. An unsightly long curved scar is now seldom seen

[The illustrations for this Chapter on Elongation of the Tendo Achillis were prepared by Mr F Price from originals by Mr R J Whitley F.R.P.S.]

SOFT TISSUE CORRECTION OF A CLUB FOOT

K. I. NISSEN F.R.C.S

Surgeon The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Indications

This operation is associated with the names of Elmslie and particularly of Brockman. The operation is employed in young children aged from two to four years for the correction of moderate inversion and adduction deformity which has persisted despite external splintage such as Denis Brown splints and corrective plaster casts. The object is to release all the soft tissue obstacles to correction which are found along the inner border of the foot, and then to obtain the best position possible by plaster of Paris casts. Residual fixed equinus may also be dealt with at the time of operation by an extension of the procedure to include elongation of the tendo Achillis and posterior capsulotomy of the ankle joint.

The operation and the splintage which follows it are effective only in young children. Sometimes no further operation is required. More often, however it must be regarded as a temporizing measure to keep the deformity under control for some years until the tarsal bones are fully ossified and a successful triple arthrodesis can be performed. In those cases which relapse despite adequate after-care, the calf muscle is often thin and wasted—a good clinical indication of the degree of muscle imbalance to be overcome.

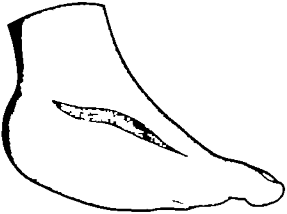
Some surgeons follow up a soft-tissue correction with transplantation of the tendon of tibialis anticus into the middle of the dorsum of the foot, the object being to reduce still further the imbalance between the weak evertor and strong invertor muscles. This procedure, however must be regarded with suspicion because of the risk of the slow development of a troublesome secondary deformity like that seen in anterior poliomyelitis after isolated paralysis of the tibialis anticus—depression of the ball of the foot by over-action of the peroneus longus and clawing of the great toe from over-action of the long extensor. When the original muscle imbalance has been slight, as shown by a well-developed calf muscle, this deformity is almost inevitable.

Contra-indications

Rigidity of the deformity from advancing ossification of the tarsal bones contra-indicates the operation in later childhood. Gross deformity and muscle imbalance cannot of course be overcome by this soft tissue alone this excludes most cases of arthrogryposis. Impaired sensibility of the skin of the foot introduces a grave risk of ulceration from pressure of the firmly moulded plaster casts this excludes most cases of club foot associated with spina bifida.

Anaesthesia

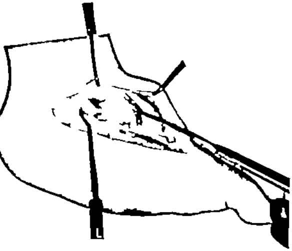
A general anaesthetic is induced and an exsanguinating tourniquet is applied to the middle of the thigh.



THE OPERATION

The Incision

1 An incision slightly curved upwards is made along the inner border of the foot from just behind the tuberosity of the navicular to the middle of the shaft of the first metatarsal bone



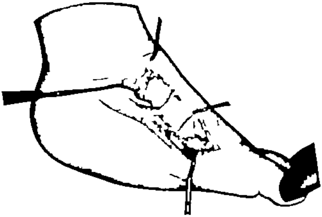
Exposure

2 The tendons of tibialis posticus and of tibialis anticus are clearly defined. The situation of the two joints between the medial cuneiform bone and the navicular and first metatarsal respectively is determined by passive movement of the foot.

Resection of soft tissues

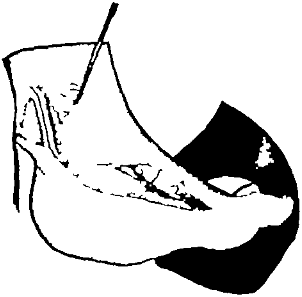
3 All the available capsule of these joints is resected.

The insertion of the tibialis posticus into the tuberosity of the navicular bone is now divided, leaving intact the extension of the tendon to the deep surface of the tarsus. This remaining part of the tendon is firmly retracted downwards and backwards, giving access to the mass of connective tissue which is always found lying in the angle between the prominent tuberosity and the neck of the talus. All this tissue is excised and with it the medial capsule of the talo-navicular joint. The anterior half of the subtalar joint is reached by following downwards the neck of the talus and its capsule is divided. Careful retraction is necessary at this stage in order to avoid any damage to the neuro-vascular bundle.



Extension of the procedure

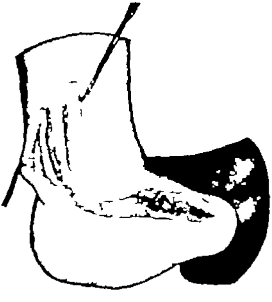
4 When there is residual fixed equinus the incision may be extended upwards along the medial aspect of the tendo Achillis, which is divided in the coronal plane as in the operation for open elongation of the tendon (see page 824)



Manipulation of the foot

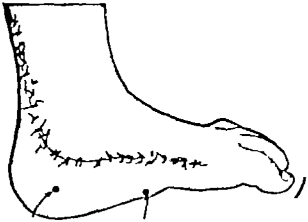
5 The foot is forced into dorsiflexion. The divided tendon should elongate. If it fails to do so the posterior capsule of the ankle joint may be exposed and divided between the lowest muscle fibres of the flexor longus hallucis and the peroneal tendons, and powerful dorsiflexion strain again applied. Two or three points of fine suture are sufficient for repair of the tendon.

It is important to avoid at all stages spurious correction of the equinus deformity by upward pressure on the foot confined to the region of the metatarsal heads. Such pressure only tends to accentuate any "rocker-sole" deformity which may be present.



Closure and fixation

6 The incision is closed and a lightly padded plaster cast is applied from below the knee to beyond the tip of the great toe on the inner border of the foot. Firm moulding of this cast is important. It is applied as follows along the inner aspect of the heel (to correct inversion) beneath the cuboid and base of the fifth metatarsal (to avoid a rocker-sole deformity and favour a calcaneo-valgus position of the foot) and along the whole of the medial aspect of the first metatarsal and great toe (to correct adduction of the forefoot)



POST-OPERATIVE CARE AND COMPLICATIONS

The stitches are removed after 2 weeks, when another below-knee plaster is applied over stockinet and a minimal amount of padding A general anaesthetic is necessary so that the foot can again be manipulated and the cast applied with firm moulding Occasionally this process needs to be repeated at intervals of a fortnight.

As a rule full weight-bearing is allowed after the application of the second cast, which is retained for a further 4–6 weeks. Sturdy lace-up boots with outside wedges of one-sixth of an inch in both sole and heel are then the most appropriate footwear This wedging is maintained until the wear of the shoe is normal.

Complications

Any tendency to relapse may be treated by a further series of corrective plasters. If the persistent deformity is sufficiently severe, triple arthrodesis may become necessary but should be deferred if possible until the bones of the foot are well ossified about the age of 8 or 10 years, or even later

[The illustrations for this Chapter on Soft Tissue Correction of a Club Foot were prepared by Mr F Price from originals by Mr R. J Whitley F R.P S]

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MULTIPLE OSTEOTOMY FOR METATARSUS VARUS

K. I. Nissen F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

When metatarsus varus occurs by itself the heel is not inverted and the foot is plantigrade, but all five metat are adducted in relation to the tarsus. The lateral border of the foot is convex, the inner is concave The defor causes a marked pigeon-toe gait in young children learning to walk and to run. This cause of "intoeing" mus be confused with the perfectly normal attitude of inversion of the whole limb often adopted for some tim sturdy children at this stage of progress.

Frequently however metatarsus varus is only one of the deformities of congenital talipes equino-varus. this reason metatarsus varus occurring alone may be regarded as a *forme fruste* of club foot. This element o general deformity sometimes persists after all the others have been corrected.

Minor degrees of metatarsus varus tend to resolve the first few pairs of shoes may be worn reversed in ord aid the process. Intermediate degrees respond to splintage either the foot pieces of a Denis Browne splint sui padded with felt or serial plaster casts may be used for this purpose.

Indications

Only those major cases which have not responded to patient corrective splinting require correction by *mul* osteotomy The operation is usually done about the age of three or four years while the foot is still relatively su

Inward rotation of the tibia may also remain after correction of a club foot when both the knee and the a are held at right angles, the whole foot, not just the metatarsus, is seen to be rotated inwards in relation to patella. This element of the deformity can, of course, be corrected by a rotation osteotomy of the tibia.

When both metatarsus varus and inward rotation of the tibia remain, both operations may be needed. metatarsal deformity is corrected first so as to leave a clear field for the rotation osteotomy a procedure w requires exact judgment.

Anaesthesia

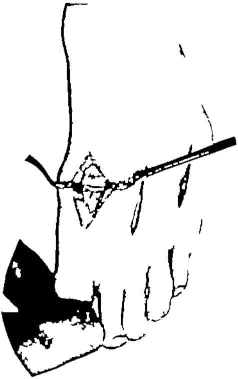
A general anaesthetic is induced and is followed by the application of a tourniquet up to the mid-thigh.

THE OPERATION

Access and osteotomy

1 For access to the base of each metatarsal three separate straight incisions may be used, one for the first, one for the second and third, and one for the fourth and fifth. The alternative is a single curved incision, convex forwards across the dorsum

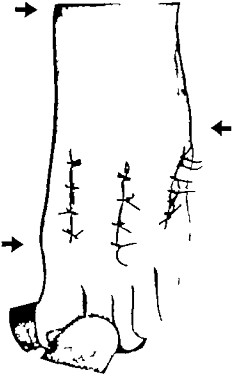
The base of each metatarsal is exposed in turn and the position of the metatarso-phalangeal joint defined. There is no need specially to conserve the thick periosteum because it resists angulation of the osteotomies. Each bone is divided transversely at the level where the shaft is expanding into the base. Care is taken not to let the sharp osteotome damage any of the plantar structures.



Correction of deformity

2 Powerful bending of the foot brings the metatarsals into line, but they tend to swing back as soon as pressure is released. It is essential to make sure that visible correction is occurring at each of the five sites of osteotomy The strong periosteum over the medial aspect of the first metatarsal often requires to be freely divided.

Efficient three-point fixation is required until the osteotomies consolidate. A below-knee plaster is applied over light padding with the sole of the foot held plantigrade, and while the plaster sets the cast is firmly moulded—outwards along the first metatarsal and over the inner surface of the heel, and inwards over the cuboid region. An antero-posterior radiograph of the foot is taken in order to confirm that angulation of the osteotomies has been maintained.



POST-OPERATIVE CARE

A below-knee walking plaster is applied over stockinet 14 days after operation, again with careful moulding Full weight-bearing is allowed over the next six weeks, when radiographs taken out of plaster confirm bony union of the osteotomies. The foot is kept under observation and any tendency to relapse is controlled by corrective plaster casts.

[The illustrations for this Chapter on Multiple Osteotomy for Metatarsus Varus were prepared by Mr F Price from originals by Mr R J Whitley F R P S]

ROTATION OSTEOTOMY OF THE TIBIA

K. I. Nissen F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

Indications

In a case of talipes equino-varus the foot may have been well corrected yet still continue to point inwards because of an internal rotation twist of the tibia and fibula The amount of rotation can be judged by examining the alignment of the foot in relation to the patella with both the knee and the ankle held at right angles. When this fixed rotation is considerable, say 20 degrees or more osteotomy of the tibia is required to permit the foot and ankle to be brought into normal alignment. Anterior poliomyelitis in children not infrequently causes an external rotation deformity requiring similar correction but in the opposite direction

In children "reed" osteotomy of the tibia is a useful method. The technique is much the same as that of 'longitudinal' osteotomy but the word "reed" aptly describes the unusual relationship of the cut bone ends. Between 8 and 10 years of age up to 40 degrees of correction can be attained without difficulty and consolidation is rapid. In the second decade the risk of delayed union steadily increases.

Special contra-indications

This method must on no account be used in adults because of the high risk of non-union of the dense and inelastic cortical bone Nor should it be used for the correction of angulation associated with rotation such as may occur in malunion of a fracture.

Special requirements and position of patient

A motor saw with a small fine blade a supply of cold saline solution and a Gigli saw are needed

The tourniquet is applied to the upper part of the thigh. The skin towels are arranged so that the whole of the limb below the tourniquet is exposed.

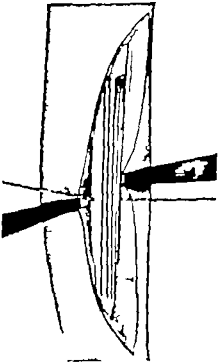
THE OPERATION

Incision exposure and osteotomy

1 A straight incision down to bone is made over the middle half of the subcutaneous surface of the tibia. The thick periosteum is reflected over this area and for a short distance all round the middle of the bone where two bone spikes are inserted.

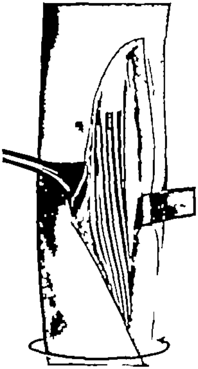
A small fine blade is selected for the motor saw and a supply of cold saline solution is made ready for delivery from a large syringe with a needle of medium size.

Six or seven strictly parallel cuts are made through one thickness of the cortex over the middle third of the bone In order to avoid over-heating the saw is made to run slowly and kept well cooled by a constant stream of the saline solution A Gigli saw is used to divide the posterior cortex transversely It, too is kept cool with saline



Correction and closure

2 The knee and the ankle are held at right angles and the whole foot is firmly rotated in the forward direction. The osteotomy should allow a few degrees of over-correction. If the thin strips or reeds of young cortical bone are not elastic enough to allow this their ends are divided alternately above and below as shown. The intact fibula gives a measure of stability to the osteotomy The periosteal membrane is replaced without any attempt at suture and the skin incision is closed.



Fixation

Light padding is applied to the limb with the knee at a right angle and a plaster of Paris cast is applied in two stages. First the knee is included by turns applied from the upper thigh to the middle of the tibia with firm moulding of the cast on either side of the lower femur The foot is then held at a right angle rotated into about 10 degrees of apparent over-correction, and secured by more turns of plaster bandage extending well down to include the toes.

POST-OPERATIVE CARE

Three weeks later when the osteotomy is firm, another full-length cast is applied over stockinet, but with the knee only slightly bent and the foot pointing directly forward. Two months from the operation radiographs taken out of plaster regularly show sound union in the case of a child and weight-bearing without protection can be resumed.

[The illustrations for this Chapter on Rotation Osteotomy of the Tibia were prepared by Mr F Price from originals by Mr R J Whitley F R P S]

Reference

Nicholson, O R. (195?). Longitudinal Osteotomy of the Tibia." *J Bone Jt Surg* 39B. (In the press.)

OPERATIONS FOR PES CAVUS AND CLAW TOES

K. I. NISSEN, F.R.C.S.

Surgeon, The Royal National Orthopaedic Hospital, London

Pes cavus and clawing of all five toes go together and frequently require correction. Two pairs of well-tried operations have been selected. The first pair—Steindler's operation and Lambrinudi's operation for claw toes—are described in this chapter. The second pair—wedge tarsectomy and amputation of all toes—are really salvage procedures for use in neglected adult cases and are described separately in the chapters on Triple Arthrodesis, and Hallux Valgus and Hallux Rigidus.

STEINDLER'S OPERATION FOR PES CAVUS

Steindler's operation for pes cavus is designed to reduce the height of the raised medial and lateral long arches of the foot. Being a soft tissue procedure, it cannot affect the secondary bone changes found in neglected late cases. It is therefore employed mainly in cases of moderate severity between late childhood and early adult life.

Indications

The operation is employed to best effect in the idiopathic type of case.

Factors which influence the decision to operate are: deformity increasing steadily from year to year; pain under the metatarsal heads; general discomfort of the foot after exercise not relieved by physical treatment such as manipulation; and the economic factor of excessive wear of the sole of the shoe right across the tread, with buckling of the upper at that level.

Contra-indications

In idiopathic pes cavus the main contra-indications are too little deformity or too much deformity. There is too little deformity if daylight cannot be seen under the cuboid region when the patient stands on a flat surface. At the other end of the scale, severe deformity in adults requires either surgical footwear, or a transverse wedge tarsectomy, or both.

Some type of cavus deformity is often found in neurological disorders. In cases of spina bifida with diminished sensibility of the skin of the foot, the operation carries a high risk of ulceration. In poliomyelitis with advanced calcaneocavus deformity, Steindler's operation is unsatisfactory if only because the paralysed calf muscles offer no resistance at the stage of wrenching. In arachnodactyly and other disorders with gross impairment of muscle tone, the operation may cause the arches to collapse and leave a condition of gross pes planovalgus. On the other hand Friedreich's ataxia, suspected or proven, is not a contra-indication.

Special equipment

A Thomas's wrench is essential; it may be kept dry and sterile in formalin vapour.

During the application of the plaster cast a flat board about 12 inches by 16 inches is required.

Anaesthesia and position of patient

A general anaesthetic is required and a tourniquet is applied to the lower thigh. On no account should any muscle relaxant be given sooner than this, because normal tone in the muscles of the calf is essential at the stage of wrenching.

The patient is placed in the lateral position, with the foot being dealt with uppermost. Because the operation is often bilateral, the arrangement of the towels should permit the patient to be turned on to the opposite side.

THE OPERATION

The lateral approach described here is that of the late Blundell Bankart. The standard techniques employ a medial incision. Steindler's original incision round the back of the heel is no longer employed.

Incision and exposure

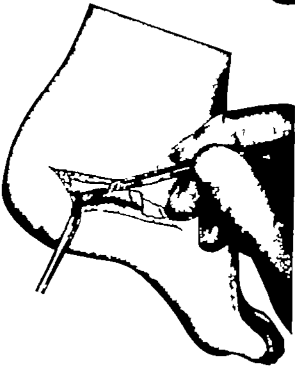
1 A straight horizontal incision is made backward from the middle of the base of the fifth metatarsal, along the upper margin of the short muscles of the sole to the lateral surface of the calcaneum. The sural cutaneous nerve may be seen in the upper anterior margin of the wound and should be kept intact so as to avoid the risk of a neuroma. The tendon of peroneus brevis is identified and, much more important, the tendon of peroneus longus where it runs obliquely under the cuboid bone. The central part of the incision is deepened over the upper margin of abductor digiti minimi until an extensive plane of free cleavage is entered underneath the calcaneum between the glistening long plantar ligament and accessorius.

NOTE.—This exposure gives excellent access to the body of the calcaneum for conditions such as bone cyst and osteoid osteoma.

Release of the short muscles and *plantar fascia*

2 The short muscles of the sole are firmly retracted downwards. A sharp scalpel is introduced into the wound and the lower skin flap is lifted off the calcaneum in the direction of the lateral tuberosity. With light strokes of the scalpel, first the lateral and then the medial tuberosities are freed, and are seen to be freed, of all accessible soft tissue. This may be confirmed by palpation of the two prominences with the end of a curved Farabeuf's rugine. Clearance of the medial tuberosity releases the taut band of plantar fascia which runs between it and the ball of the great toe.

NOTE.—This part of the operation alone may be used for intractable cases of plantar fasciitis, with or without spur formation.



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During the application of the plaster cast a flat board about 12 inches by 18 inches is required.

Anaesthesia and position of patient

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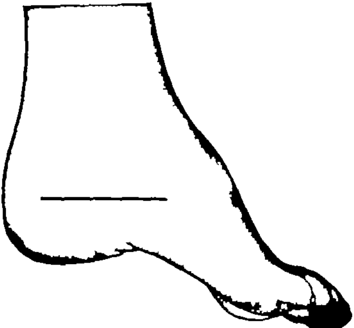

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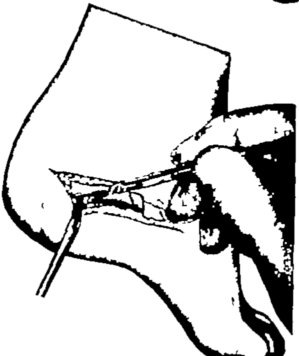
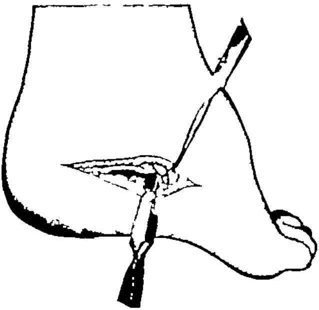


Division of the plantar ligaments

3 The tendon of peroneus longus is drawn upwards and forwards with a blunt hook. The sharp edge of a curved rugine is applied to the shining white surface of the long plantar ligament and run forwards along it until a slight transverse depression indicating the calcaneo-cuboid joint is reached. With firm pressure the sharp rugine is forced into the joint, so partly dividing the long and short plantar ligaments as they cross beneath it.

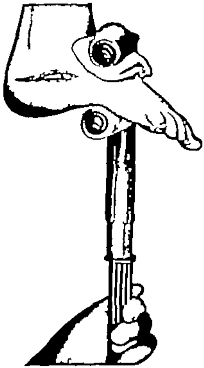
The remaining fibres of these thick and strong ligaments are now divided under full vision. The back of the scalpel is held towards the tendon of peroneus longus, which must not be damaged. The main obstacle to flattening of the lateral arch has now been removed.



Application of the Thomas's wrench

4 The wrench is now applied to the foot. It has two transverse bars, each covered with thick rubber. The end one is fixed, but the other can be moved by turning the ridged handle of the wrench. In Tubby's model, illustrated here, the end bar is curved to conform with the dorsum of the foot.

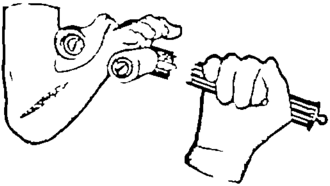
One bar lies across the dorsum, the skin of which is protected by a soft gauze swab. The other bar is adjusted so as to lie snugly behind the prominent ball of the great toe. The long member of the wrench sits against the inner border of the foot.



Wrenching of the foot

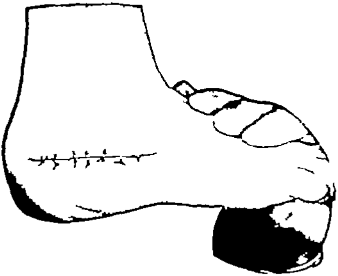
5 Powerful leverage is now applied so as to force the foot into a position of extreme calcaneus *against the resistance of the calf muscles*. If the bar under the sole tends to slip around the ball of the great toe the distance between the two bars is reduced. The procedure is accompanied by the sounds of stretching of soft tissues. *The skin of the inner margin of* the sole is kept under observation if it tends to split further manipulation is delayed for a fortnight. At the end of the manoeuvre both the long arches appear to be completely obliterated by the continued pressure.

Failure to obtain correction at this stage is due to loss of the powerful leverage available. This can occur for three reasons—incomplete release of the soft tissues of the sole, weak calf muscles offering no resistance to the calcaneus position, and above all timid use of the wrench. Controlled vigour is essential. With it, there is very little risk of damage such as fracture of a metatarsal, abrasion of the dorsum of the foot or rupture of the skin at the apex of the medial long arch.



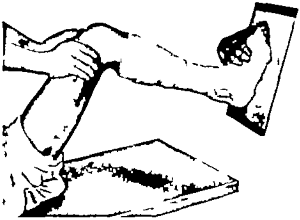
Closure

6 The foot is returned to the neutral position and the wound is sutured with interrupted mattress sutures. The foot is now seen to be longer and any flexion deformity of the toes at the interphalangeal joints is temporarily increased owing to the raised tension in the flexor *tendons*.



Application of the plaster cast

7 The patient is turned on his back. A lightly padded plaster of Paris cast is applied from below the knee to the toes, with a double layer of padding over the dorsum of the foot and a good thickness of plaster under the sole. The moulding of the cast is important. An assistant holds the limb flexed nearly to a right angle at the hip and knee. The surgeon holds the foot in the neutral position against a flat board over the front of his chest, while his assistant pushes the foot on to the board by firm downward pressure on the bent knee. In this way the plaster beneath the foot is well flattened out, like a sole plate applied to the heel behind and the metatarsal heads in front. While the plaster is setting the surgeon moulds the plaster firmly and evenly over the dorsum of the foot so as to hold three point correction. The toes are left free.



POST-OPERATIVE CARE AND COMPLICATIONS

Insufficient dorsal padding and uneven or excessive moulding may cause the threat of a pressure sore, in which case the cast is at once split down either side. After 2 weeks a below-knee walking plaster is applied in the same way as the post-operative cast but with very little padding This cast is retained for 4 weeks of full weight-bearing during which time the patient is encouraged to exercise and stretch the toes.

Hot and cold foot baths and exercises are used to control any post-operative swelling or stiffness and the return of function is usually rapid. After successful correction normal footwear can be worn a metatarsal bar is seldom necessary

A pressure sore, either on the dorsum or under the ball of the great toe is the commonest complication and is avoidable. A painful neuroma on the sural cutaneous nerve occasionally develops and requires resection of the nerve at a higher level

LAMBRINUDI'S OPERATION FOR CLAW TOES

Indications

Clawing of all five toes frequently accompanies pes cavus. The deformity is one of hyper-extension at all the metacarpo-phalangeal joints and flexion at all the interphalangeal joints This attitude strongly suggests impaired action of the intrinsic muscles, in particular the lumbricals.

In a proportion of untreated cases the deformity slowly advances, so that in adult life all the metacarpo-phalangeal joints may show irreducible dorsal subluxation, together with painful dorsal corns and plantar callosities Surgical footwear must then be worn if this fails to give comfort, amputation of all the toes may have to be considered.

In children, however the toes are still supple and growth is proceeding If an operation is required Girdlestone s transplant of the flexor tendons into the extensors is the one of choice

In adolescents and young adults the flexion deformities of the toes often become fixed, though the hyper-extension of the metacarpo-phalangeal joints can still be reduced by simple measures. This is the last opportunity for correction.

Lambrinudi s operation is ingenious and effective. All the interphalangeal joints are excised, and while they are consolidating, the toes are held straight by subcutaneous loops of stout suture material placed directly over each proximal phalanx and tied down to a special sole-plate. This technique avoids the need for any downward pressure over the dorsal skin incisions and gives ample time for permanent correction of the extension deformity of the metacarpo-phalangeal joints. Lambrinudi claimed that the operation was often followed by arrest and even reduction of the pes cavus deformity

Simpler procedures than Lambrinudi s are unsatisfactory For example, when the outer four toes are treated by tenotomy of the extensor tendons and spike arthrodesis of the proximal interphalangeal joints, some of the extension deformity remains and the terminal joints tend to flex even more into mallet-toe deformities.

Special contra-indications

The operation is contra-indicated in children while growth is still proceeding and in adults when the extension deformities have become irreducible. Any loss of sensibility of the sole of the foot is a contra-indication because of the risk of pressure sores from continued contact with the sole-plate The claw-toe deformities occurring with conditions other than idiopathic pes cavus are seldom suitable for operation.

The operation is not indicated in those cases in which the outer four toes show marked hammer-toe deformities while the great toe stays more or less normal. Such cases seldom show any pes cavus deformity and may be properly treated by multiple spike arthrodesis.

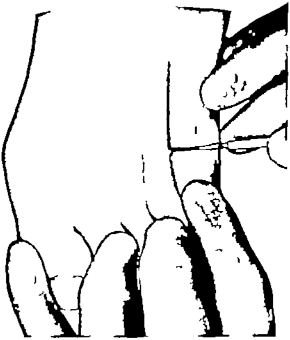
Special equipment

A Lambrinudi sole-plate is generally made to measure some time in advance it need not be sterilized. Stamm s end-cutting instrument and Capener s small osteotomes are used for excision of the interphalangeal joints. Thick adhesive felt is needed for adjustment of the sole-plate.

Anaesthesia and position of the patient

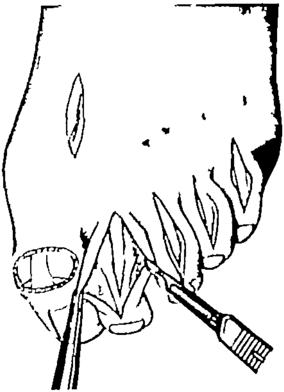
A general anaesthetic is required and not less than an hour should be allowed for each foot. An exsanguinating tourniquet is applied up to the lower thigh. The patient lies supine and the surgeon settles down on his stool at the end of the table

THE OPERATION



Closed tenotomy of the extensors of the outer four toes

1 The tendons are made prominent by downward pressure on the toes. A tenotome with a short, narrow blade is introduced on the flat underneath each tendon or pair of tendons, and the sharp edge is then turned toward the skin surface. The taut tendons are divided more by downward pressure against the blade than by to-and-fro cutting this avoids laceration of the skin. The four metacarpo-phalangeal joints are in turn fully flexed by powerful downward pressure on each toe.



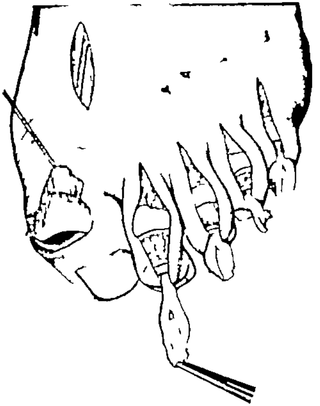
Open tenotomy of extensor hallucis longus tendon exposure

2 Open tenotomy is here preferred to closed tenotomy A short incision is made the tendon is divided by a long oblique cut, and the great toe is forced downwards into flexion. If the toe still cannot be held straight at the metacarpo-phalangeal joint with light pressure, the short incision is extended forwards and the posterior capsule of the joint is divided.

The operation may have to be abandoned at this stage if the hyper-extension deformities prove too resistant.

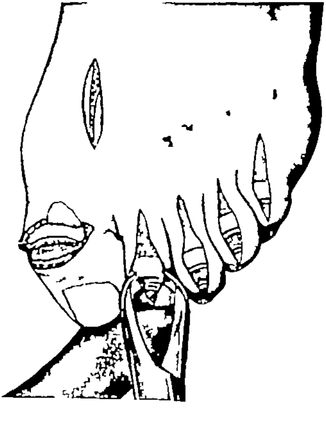
Four straight dorsal incisions are made down the length of the outer four toes and their extensor tendons are displayed.

As a rule a narrow transverse ellipse of skin is removed over the interphalangeal joint of the great toe. When posterior capsulotomy has been performed, however the longitudinal incision is simply extended on to the distal phalanx.



Exposure of the Interphalangeal Joints

3 The extensor tendons are resected and all the interphalangeal joints are laid open with the exception of the tiny distal joint of the little toe. The contracted lateral ligaments of each joint are divided with a small scalpel held close to the bone this gives just enough access for excision of the joints. With any more dissection some of the small bones become uncontrollable.



Excision of the Joints

4 The joints are now excised so as to give flat surfaces which fit well with the toes held straight. A minimal amount of bone is removed in order to avoid undue shortening For the larger joints Stamm s end-cutting instrument is excellent. The smaller joints are excised by hand with a Capener miniature osteotome caution should be observed as should this instrument slip the skin of both patient and surgeon may suffer

This stage demands care and patience.

TRIPLE ARTHRODESIS

K. L. NISSEN F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital, London

Surgical anatomy

The subtalar and mid-tarsal joints working in close harmony allow the complex movements of inversion and eversion of the foot. The mid-tarsal joint of Chopart consists, however of two separate articulations, the talo-navicular medially and the calcaneo-cuboid laterally. Excision of all three joints is called "triple arthrodesis" in the English and "double arthrodese" in the French literature.

Anatomically the subtalar and talo-navicular joints together may be regarded as consisting of the small posterior talo-calcaneal joint and the large talo-calcaneo-navicular joint, separated by the wide sinus tarsi containing the inter osseous ligament. From the operative point of view this unequal division has considerable merit, as will appear later.

Loss of function of any one of the three joints affects the other two and sooner or later leads to secondary arthritic changes in them. A good example is congenital fusion between the talus and the calcaneum by early adult life the talo-navicular joint is often arthritic and painful enough to demand excision. This is the main reason why triple arthrodesis is so much preferred to the simple operation of subtalar arthrodesis, especially in young patients.

Rationale of the operation

A successful triple arthrodesis acts in three ways. *Pain* arising in any of the three joints is relieved. *Stability* of the tarsus is ensured this may enable external splintage to be dispensed with. *Deformity* of the tarsus is corrected by the removal of appropriate wedges of bone. Because the tarsus is so commonly affected by pain, instability and deformity triple arthrodesis and its variants are most valuable operative procedures.

Indications for operation

The circumstances under which triple arthrodesis is indicated are too numerous to mention individually but may be discussed under the same three headings.

Pain

A fracture involving any one of the joints may cause enough persistent pain and limitation of activity to demand relief by triple arthrodesis. The subtalar joint is a frequent source of pain it is often affected from below by a fracture of the calcaneum, less often from above by a fracture of the talus. Peroneal spastic flat foot with pain referred mainly to the talo-navicular region is another common reason for triple arthrodesis in adolescent and early adult life the exciting cause is usually some demonstrable bony abnormality such as partial or complete fusion between the calcaneum and the navicular.

Instability

Muscle imbalance is the common cause of instability of the tarsus. Anterior poliomyelitis and spastic paralysis provide most of the background. Triple arthrodesis may be indicated in order to free the patient from some type of external support such as short steels to the calf or a surgical boot. The muscle imbalance often needs to be reduced by a supplementary tendon transplantation for example, transfer of the insertion of tibialis anticus muscle to the middle of the dorsum of the foot is required in every case of peroneal muscular atrophy.

Deformity

Practically any deformity of the tarsus can be corrected by the removal of a wedge of bone either from the subtalar or from the mid-tarsal joint, sometimes from both.

Thus *inversion of the heel* is reduced by closure of a lateral subtalar wedge *cavus* by a dorsal mid-tarsal wedge mainly from the talus and the navicular *adduction of the forefoot* by a lateral mid-tarsal wedge, mainly from the calcaneum and the cuboid *equinus* by an anterior subtalar wedge taken mainly from the head of the talus (as in Lambrinudi s drop-foot operation *see* page 358) and *calcaneus* by a posterior subtalar wedge taken mainly from the body of the calcaneum (as in Elmslie s operation and Lambrinudi s reversed drop-foot operation *see* pages 48 and 49)

The compound deformity of equinocavovarus with adduction of the forefoot may obviously require the planned removal of no less than four wedges—the first four mentioned here

These wedges are cut with straight osteotomes leaving plane surfaces of cancellous bone which must fit accurately if sound fusion is to be obtained. Considerable skill and judgment are required.

The earliest age for correction of deformity

The deformities that may require tarsectomy can be divided into two groups—congenital and acquired. In the congenital group, which includes resistant talipes equinovarus and arthrogryposis, the question of the earliest age for bony correction constantly arises. Sometimes the deformity is so gross that the most that can be expected of the foot is something plantigrade and comfortable that will permit walking a radical tarsectomy as early as 3 or 4 years is then justifiable. Usually correction is deferred as long as possible towards adolescence so as to avoid interference with bone growth. The same policy is followed in cases of truly infantile anterior poliomyelitis unless, of course, the deformity can be arrested by restoring muscle balance.

Special contra-indications

In young children the tarsal bones are not fully ossified fusion is difficult to obtain, growth of the foot is disturbed, and recurrence of deformity is frequent.

Any condition which might leave the rest of the foot stiff and painful after 3 or 4 months of immobilization is a contra-indication. The active rheumatoid state and post-traumatic osteoporosis are good examples.

Other contra-indications, such as local skin sepsis or vascular insufficiency follow general surgical principles. The operation is rarely indicated after the age of sixty

Surgical access to the subtalar joint

Adequate surgical access to the tarsal joints can only be gained from the lateral aspect. The calcaneo-cuboid and talo-navicular joints present little difficulty The main problem is how best to approach the subtalar joint, particularly because the lateral relations of the posterior component of the joint include the important middle fasciculus of the lateral ligament of the ankle joint and the peroneal tendons in their sheaths.

Wide lateral access permitting frank dislocation of the subtalar joint entails a curved incision behind the lateral malleolus with considerable displacement of the peroneal tendons and division of the ligament (*see* page 354) *Limited* access to the joint, entirely adequate for most types of triple arthrodesis, can, however be gained with these structures left undisturbed through a curved incision in front of the lateral malleolus.

The antero-lateral approach

The technique to be described employs this antero-lateral access through a "silent area" in which no important cutaneous nerves, tendons or ligaments are encountered. The edge of the anterior flap is relatively close to its blood supply from the dorsalis pedis vessels this reduces the risk of skin necrosis. The subtalar joint is not dislocated inwards, a manoeuvre which in any case is difficult to perform when there is marked stiffness of the joint as in an old fracture of the calcaneum, and quite impossible in calcaneo-navicular fusion without division of the bar of bone.

Special requirements

A selection of curved and straight osteotomes half to one inch wide are required for excision of the joints. Small bone spikes and retractors are required to give access and to protect the soft tissues.

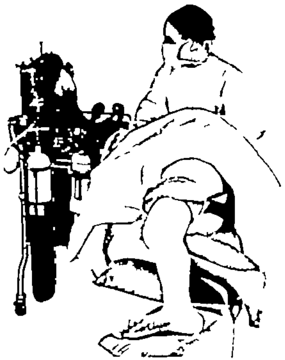
THE OPERATION

TECHNIQUE OF ANTERO-LATERAL APPROACH

Anaesthesia and position of patient

1 A general anaesthetic is used. If tendon transplantation is to be performed at a later stage in the operation, no muscle relaxant is given prior to the application of an exsanguinating tourniquet to the lower thigh.

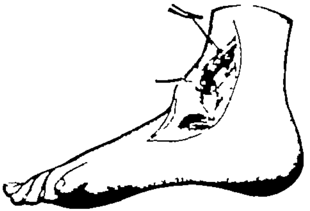
The patient is placed in a lateral attitude with the lower limbs arranged like a figure 4 The sound limb is underneath, flexed to a right angle at the knee with a long sand-bag on either side of the leg The affected limb is on top, with the knee straight and the foot supported on a square sand-bag



Incision and ligation of vessels

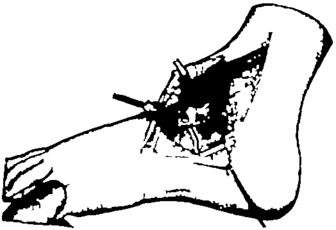
2 The skin incision is antero-lateral The upper part of the incision is 3 or 4 inches long down the anterior border of the fibula. The lower part curves medially across the muscle belly of extensor brevis.

The transverse fibres of the superior extensor retinaculum are reflected from the fibula and the fragile perforating branch of the peroneal artery is found just above the inferior tibiofibular joint. It is divided between ligatures. Often it is the only vessel which needs to be tied during the operation.



Exposure of the mid-tarsal joint

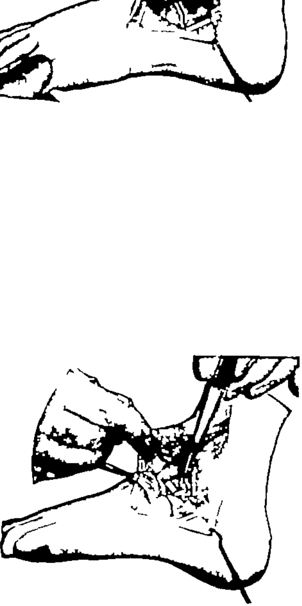
3 The anterior skin flap is retracted and an extensive plane of free dissection is entered over the lower end of the tibia. It is followed downwards over the thin anterior capsule of the ankle joint and the dorsal aspect of the talo-navicular joint on to the navicular itself. The posterior skin flap is now retracted. The tendon sheath of peroneus brevis is defined. The lateral sural cutaneous nerve is in this neighbourhood and must be avoided. Extensor brevis is elevated and reflected forwards from the calcaneum, working from the posterior and inferior borders of the muscle. In this way its nerve supply entering medially is respected. The mid-tarsal joint is then opened widely by free resection of the capsules of the talo-navicular and calcaneo-cuboid joints. Any remains of the bifurcate ligament are also removed.



Exposure of the subtalar joint

4 The sinus tarsi is now completely denuded of all tissue, including the interosseous ligament, by coring it out with a narrow scalpel held close to the bone. This aids the access to the under surface of the head of the talus and to the sustentaculum tali.

The narrow posterior talo-navicular joint is discovered by movement of the foot and its anterior capsule is resected. The joint lies medial to the tip of the lateral malleolus, and can therefore be entered from in front without disturbing either the important middle fasciculus of the lateral ligament of the ankle joint or the peroneal tendons.



Resection of the three joints

5 Firm inversion strain is now maintained by an assistant. This opens out the tarsal joints enough to give access for resection.

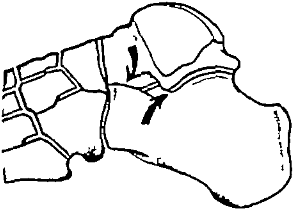
The aim is first to remove all available articular cartilage together with a thin layer of subchondral bone, and then to secure many points of later bone contact. This is done by roughening each cancellous bone surface with an edge of the osteotome until it resembles a very coarse rasp. *Damage of the soft tissues by the sharp osteotome must be avoided.*

The calcaneo-cuboid joint is first dealt with. A spike is inserted beneath the joint to protect the tendon of peroneus longus.

The talo-navicular joint comes next. It curves round medially so that forced inversion of the foot and a curved osteotome are necessary for its complete excision.

The two components of the subtalar joint are now reached by working in the direction of the arrows shown in this illustration. The upper surface of the sustentaculum tali can be reached, but only the front half of the arched posterior talo-calcaneal joint is accessible and need be resected. To this extent the resection of the subtalar joint is incomplete.

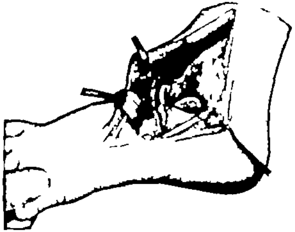
(When deformity has to be corrected one or more of the wedges already mentioned are excised with a straight osteotome. The apex of each wedge must of course reach fully to the other side of the tarsus—otherwise the flat surfaces cannot be apposed without considerable force. A common fault is to leave the heel inverted by removing too narrow a lateral wedge from the subtalar joint.)

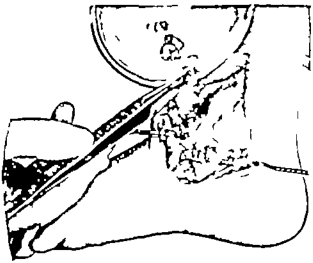


Preparation of the sinus tarsi

6 The wide entrance to the sinus has a roof of talus and a floor of calcaneum. Both are denuded of a thin shell of cortical bone and roughened ready for packing with tibial bone chips. The object is to form a massive talo-calcaneal bar.

(If a wedge has been removed from the subtalar joint this procedure is obviated.)





Cancellous bone chips

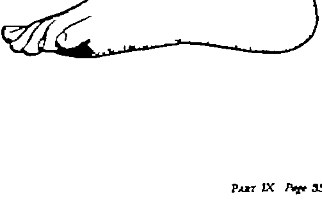
7 A quantity of cancellous bone chips is obtained from the lower end of the tibia an excellent local source already exposed in the upper end of the incision. In younger subjects the tibial epiphysis must of course be respected. The cavity fills in during the subsequent period of fixation in plaster

The chips are packed firmly into the sinus tarsi where they ensure fusion between the talus and calcaneum. Any chips left over are used to fill in the margins of the three joints.

Closure and fixation

8 Extensor brevis is replaced by a few catgut sutures and the incision is closed in two layers. The gauze dressings are placed in the line of the limb, not round it otherwise, after being soaked in blood, they may contract and constrict the ankle region.

A below-knee padded plaster is applied with the foot in the neutral position, making use of a flat board under the sole of the cast to give firm apposition of the calcaneum to the talus (see page 842) The cast is partly divided down the length of each side in case it has to be bivalved urgently Radiographs may be taken later in two planes through the cast to confirm the position.



TECHNIQUE OF POSTERO-LATERAL APPROACH

Wide access to the subtalar joint may be gained through a curved incision behind the lateral malleolus, an approach which is used as a routine by many surgeons. The exposure of the mid-tarsal joints and clearance of the sinus tarsi follows closely the steps already described (Illustrations 2, 3 and 4). The peroneal tendons are then mobilized and the posterior talo-calcaneal joint is freely entered by dividing the lateral ligament of the ankle joint.

The foot is then dislocated inwards on the talus, which, if the division of soft tissues has been sufficiently extensive, and if the subtalar joint is not too rigid, remains seated in the ankle mortise. The dislocation is complete when the foot has rotated through two right angles and is lying alongside the tibia with the direction of the sole completely reversed. The subtalar joint can then be resected with the greatest of ease.

This wide exposure is essential for the correction of calcaneus deformity by removal of a posterior wedge from the calcaneum, but is more than is necessary for routine use. In skilled hands the superb access is obtained regularly at little cost—otherwise the risks are those of necrosis of the margin of the anterior skin flap, impaired function of the peroneal tendons, lateral instability of the ankle joint, neuroma of the lateral sural nerve and impaired nutrition of the talus.

POST-OPERATIVE CARE AND COMPLICATIONS

The limb is kept elevated and cool. The cast as a rule becomes heavily blood-stained, but this need seldom cause alarm. The circulation in the toes must be watched and the cast divided at the first sign of embarrassment.

After two weeks a below-knee walking plaster is applied over stockinet with careful moulding to all the bone contours. Full weight-bearing is encouraged over the next three months, with active exercises of the toes and knee to maintain muscle tone. Radiographs taken out of plaster then confirm bone union, and residual stiffness of the other joints is dispersed by vigorous exercises performed in the course of taking hot and cold contrast foot baths.

Special complications

Damage to the soft tissues can provide a wide variety of early complications. The most troublesome is a patch of necrosis of the anterior flap near the lateral malleolus. The residual ulcer usually heals soundly in repeated closed plasters; plastic repair is seldom necessary.

The late complications may be given under three headings:—

Continued pain.—This may be due to fibrous ankylosis, particularly of the talo-navicular joint. An occasional source of obscure pain is a neuroma of the lateral sural nerve.

Persistent instability.—The usual causes are failure to deal with muscle imbalance by appropriate tendon transplantation and failure to correct inversion of the heel. Lateral instability of the ankle from damage of the lateral ligament may require fusion of that joint; the end result is a pan-talar arthrodesis.

Recurrence of deformity.—The usual cause is again muscle imbalance, most often from strong invertor muscles. A wedge resection followed now by tendon transplantation may have to be embarked on. This is often required when triple arthrodesis has been performed at an early age, say five or six years, for congenital talipes equinovarus.

SPECIAL TYPES OF TRIPLE ARTHRODESIS

DORSAL WEDGE TARSECTOMY

The essential part of this operation is the removal of a wide transverse dorsal wedge from the mid-tarsal region, mainly at the expense of the head of the talus.

The operation may be indicated for severe pes cavus in an adult with secondary changes in the shape of the tarsal bones in order to reduce the deformity and to relieve intractable pain from callosities under the first and fifth metatarsal heads. The foot ends up short and broad. The operation does not improve fixed clawing of the toes, which in this type of case may be severe enough to warrant amputation of all of them (*see* page 811)

The special feature of the operation is complete excision of the navicular which permits backward displacement of the rest of the foot beneath the talus.

DUNN'S ARTHRODESIS

In a case of flail foot Dunn's arthrodesis may be performed with the object of bringing the centre of gravity of the foot more in line with the tibia. This reduces the tendency for the foot to fall into the position of equinus. A disadvantage of the procedure is the increased backward prominence of the heel, which of course affects the fit of the shoe To some extent Lambrinudi's drop-foot operation achieves the same object.

In severe late cases of equinovarus deformity excision of the navicular may have to be performed under duress in order to correct adduction of the fore-foot. The unusual shape and medial subluxation of the bone in such cases is largely responsible The articular part between the talus and the cuneiform bones is relatively thin, whereas the medial part related to the tuberosity is large and bulky and anchored to the tendon of tibialis posticus. This makes straightening of the inner border of the foot difficult. A Lambrinudi drop-foot operation, considerably modified, may however solve this problem in a different way

LAMBRINUDI'S DROP-FOOT OPERATION

The equinus deformity is reduced, not at the ankle joint where it occurs, but in the tarsus, by the removal of a broad anterior wedge from the subtalar joint.

The operation was designed for the correction of full equinus of the foot, for example in poliomyelitis when the calf muscle is the only active group below the knee. Lesser degrees of equinus are of course very common and may be reduced by modifications of the full procedure.

Because equino-*varus* is so common, the operation is often further modified by the removal of a varus wedge, that is a lateral subtalar wedge, in order to correct inversion of the foot it may also be followed by transplantation of the tendon of tibialis anticus to the middle of the dorsum some weeks later For these reasons, and those given under Dunn's arthrodesis, Lambrinudi's method of dealing with equinus has wide applications.

PANTALAR ARTHRODESIS

This extensive procedure is a combination of arthrodesis of the ankle joint and triple arthrodesis. It is most frequently indicated for instability in cases of poliomyelitis (*see* page 89) and for pain in cases of traumatic arthritis affecting both the ankle and the tarsal joints.

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The limb is kept elevated and cool. The cast as a rule becomes heavily blood-stained, but this need seldom cause alarm. The circulation in the toes must be watched and the cast divided at the first sign of embarrassment.

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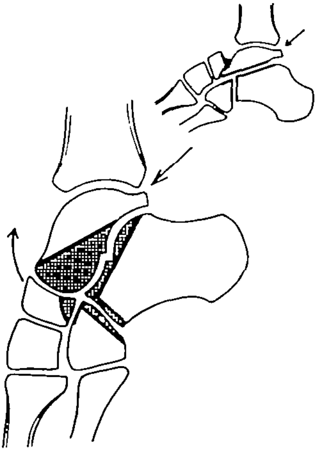
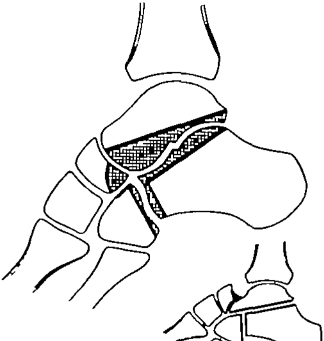


Advantage is taken of the fact that full plantar
flexion of the talus comes to a halt when the
posterior tubercle impinges against the pos-
terior margin of the lower end of the tibia (*see*
arrow) The talus in this position is relatively
stable it is used as a fixed point of support for
the *remainder of the foot* after the excision of
1 a wide anterior transverse wedge of bone from
the subtalar region, mainly at the expense of
the head of the talus. The wedge is kept closed
2 by seating the navicular on the dorsal surface
of the talus as shown, after the removal of a
postero-inferior segment.

The amount of correction varies according to the angle of the wedge The greatest angle is obtained when the point of the wedge is within the talo-calcaneal joint and when almost the whole of the head of the talus is resected. The navicular then sits well back on the neck of the talus close to the capsule of the ankle joint.

Note.—The amount of correction shown in this diagram of state of full equinus often becomes considerably reduced by the slow development of laxity of the capsule and other soft tissues anterior to the joint. This allows the ankle joint to open out in front when the limb is not bearing weight. Such laxity introduces a wide margin of error into calculations of the optimum angle of the wedge in practice the angle needs to be much greater than the one estimated from a study of the lateral radiograph.

1 Lesser degrees of correction are obtained when the point of the wedge is behind the talo-navicular joint and only the lower part of the *head of the talus is removed.*



2 Note.—This small angle of wedge is shown in many diagrams of the operation, and is often quite adequate in cases of congenital talipes *equinovarus and other condi*tions of partial equinus. In a case of full equinus, however the final effect may be little more than that of a simple triple arthrodesis.

Points in technique

When a postero-lateral approach is used, the access is so wide that section of the talus can even be made with a saw

With the antero-lateral approach the tarsal joints are exposed.

The next step is to remove the lower half of the head of the talus by a *preliminary trans*verse cut with a straight osteotome This at once reveals the lower half of the articular surface of the navicular and gives improved access to the remainder of the subtalar joint.

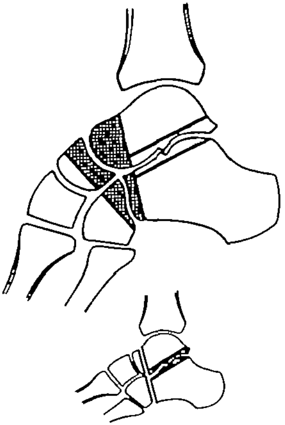
THE OPERATIONS

DORSAL WEDGE TARSECTOMY

Technique

1 The apex of the wedge, which is near the plantar surface of the calcaneo-cuboid joint, needs to be made broad, otherwise the contracted soft tissues of the sole will not permit closure of the wedge.

When the cavus deformity is gross, the whole of the scaphoid may need to be excised, allowing the cuneiform bones to be approximated to the talus.

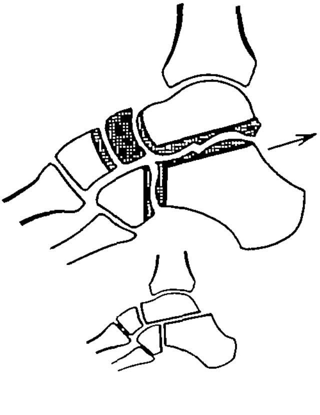


Access

The lateral access is shown on page 357
The process of freeing the scaphoid bone from the medial soft tissues, in particular the insertion of tibialis posticus, is greatly aided by a separate short horizontal incision just above the tuberosity

Treatment of the subtalar joint

2 Sometimes nothing more than removal of the dorsal wedge is required and the subtalar joint may be left more or less intact. When the heel is inverted, however a full triple arthrodesis should certainly be completed by removal of a lateral wedge as indicated.



DUNN'S ARTHRODESIS

Points in technique

Wide surgical access is required for the planned procedure. The first step is excision of the navicular If this proves difficult a small medial incision is made for disinsertion of tibialis posticus and division of the related joint capsules.

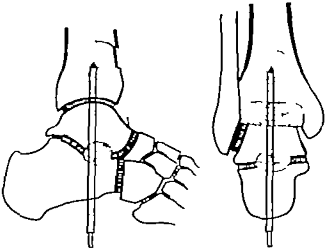
The head of the talus and the posterior surfaces of the three cuneiform bones are made as congruous as possible. Backward displacement of the foot under the talus brings these bones into contact. At the end of the operation every chink is filled in with cancellous chips from the excised bone. Without this special care one or more of the cuneiform bones may fail to consolidate this may cause painful symptoms, particularly when the medial cuneiform remains unstable.

PANTALAR ARTHRODESIS

The operation may be performed in one stage through an antero-lateral incision using a combination of the techniques of arthrodesis of the ankle joint and simple triple arthrodesis. A Steinmann pin driven upwards through the calcaneum and the talus into the tibia is used to control the position of those bones during the first two or three weeks.

Meticulous fixation in plaster of Paris is essential with accurate moulding to all contours. Precautions to ensure sound bony fusion include extension of the standard below-knee cast to the thigh, and delay in weight-bearing for three months.

Frequently the same state of pan-arthrodesis is arrived at in two stages separated by a considerable interval of time. Either the triple arthrodesis following fusion of the ankle or vice versa. The same care with fixation in plaster of Paris is essential.



[The illustrations for this Chapter on Triple Arthrodesis were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S the diagrams were drawn by Mr Price]

Bibliography

Dunn, N (1928). *Suggestions Based on Ten Years Experience of Arthrodesis of the Tarsus in the Treatment of Deformities of the Foot The Robert Jones Birthday Volume* p 395 London Oxford University Press.

Fitzgerald, F P., and Seddon, H. J. (1937) "Lambrinudi s Operation for Drop-foot." *Brit J Surg.*, 25, 283.

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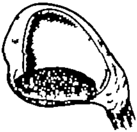
Stamm, T T (1949). "Paralytic Deformities of the Foot." In *British Surgical Practice*, Vol. 4 p. 156. London Butterworth.

Resection of the postero-inferior segment of the navicular

Successive thin slices of bone are then removed according to the needs of the case. Part of the upper surface of the cuboid often has to be cut flat in order to allow full closure of the wedge.

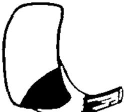
The resection of the postero-inferior segment of the navicular requires special attention. The roof of this "cave" has to fit over the dorsum of the talus. It should therefore be curved upwards and extend well over towards the tuberosity. The floor of the "cave" consists of soft tissue—not bone as some misleading diagrams of this operation would undoubtedly suggest.

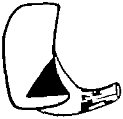


Faults in technique

A common error, especially when medial access to the bone is difficult as in severe talipes equinovarus, is to make the roof slope steadily downwards and inwards. The navicular then tends to slip inwards off the neck of the talus.

Another error is to fashion the "cave" in the substance of the lower part of the navicular. Such an appearance, it is true, may be seen in a lateral radiograph of an operation correctly performed, but it is caused by overlap of the large medial part of the navicular. This fault in technique is one of the reasons for failure of mid-tarsal fusion.





During fixation in plaster backward pressure of the foot is maintained as long as possible. On no account must the foot at any stage be held suspended by the toes lest the talus should disengage from the "cave". Loss of position can easily occur and for this reason penetrating films in two planes should always be taken through the plaster cast to make sure that the navicular and the talus have maintained their correct new relationship.

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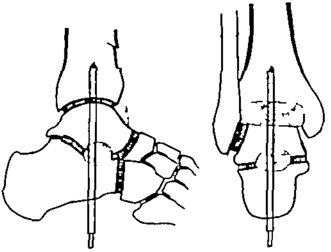

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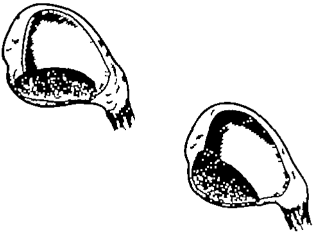

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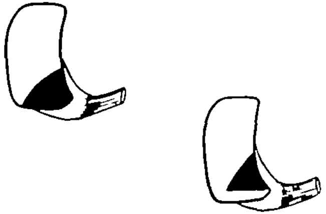

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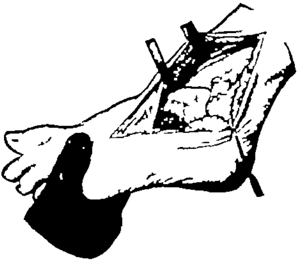
THE OPERATION

The incision

1 The incision is antero-lateral and about 6 inches long. The upper half runs straight down the anterior margin of the fibula to the joint. The lower half curves inwards towards the middle of the dorsum.

Exposure of the joint

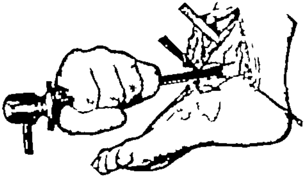


2 The fibular attachment of the extensor retinaculum is detached and the perforating branch of the peroneal artery is defined just above the inferior tibio-fibular joint. The artery is fragile, and being the main source of post-operative haemorrhage, it is ligated with care.

The anterior surface of the lower end of the tibia is exposed by making good use of the extensive plane of loose cleavage between the periosteum and the extensor tendons. The line of the ankle joint is recognized by moving the foot up and down. The whole of the anterior capsule is removed, exposing the front part of the articular surface of the talus. The vertical joint between the lateral malleolus and the talus is also opened widely.

At this stage, good anterior access to the ankle joint has been obtained, except for the small medial vertical component, which is allowed to remain hardly disturbed.

Excision of the joint



3 The joint between the lateral malleolus and the talus is excised with a straight osteotome all the articular cartilage and a layer of subchondral bone being removed in thin strips. This leaves a narrow vertical space approximately $\frac{1}{4}$-inch wide between the malleolus and the talus.

ARTHRODESIS OF THE ANKLE JOINT

K. I. NISSEN, F.R.C.S.

Surgeon, The Royal National Orthopaedic Hospital, London

PRE-OPERATIVE

Indications

The operation may be indicated in adults for pain, deformity or instability.

The common cause of pain is late traumatic arthritis following either a Pott's fracture affecting the ankle mortise, or an injury affecting the bone it contains—the talus. Less frequently, tuberculous, septic or non-specific infective arthritis leaves a painful joint.

The common cause of deformity is also trauma, though bizarre types of club foot, neglected cases of septic arthritis and so on may demand correction at this level. The deformity may of course excite pain elsewhere in the foot: severe varus deformity is associated with pain under the fifth metatarsal bone; severe equinus deformity with pain in the mid-tarsal joint.

A common cause of instability is a joint left flail by poliomyelitis. For this condition arthrodesis of the ankle is rarely performed by itself, but is combined with triple arthrodesis at the same time (pantalar arthrodesis) in order to stabilize the whole foot in some equinus. Such fixed equinus is a great advantage when the quadriceps is paralysed because it aids backward locking of the knee joint (see page 89). Cases of gross ligamentous laxity following trauma may also come to arthrodesis.

Contra-indications

In Charcot's arthropathy the chances of a successful arthrodesis are negligible. Other contra-indications are based on general principles. The operation often has to be deferred for months or years until a fracture unites, skin cover is restored, infection and oedema subside or growth stops.

Anaesthesia

A general anaesthetic is required. A tourniquet is applied up to the middle of the thigh.

Position of patient

The patient is placed in the lateral "Figure 4" position with the foot resting on a sand-bag (see page 360, Illustration 1).

Choice of method

There are many differing techniques for arthrodesis of the ankle joint. The one described here is simple and effective in routine use. Like many other methods it may fail when triple arthrodesis of the foot has already been performed, particularly when firm external fixation in a plaster of Paris cast cannot be attained. In this circumstance one of the bone-grafting techniques may be employed, either Crawford Adams's fibular graft screwed on laterally or Watson-Jones's tibial graft slotted in anteriorly.

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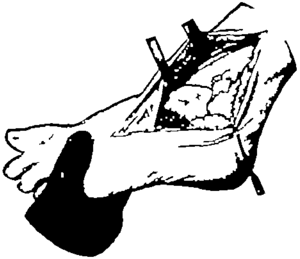

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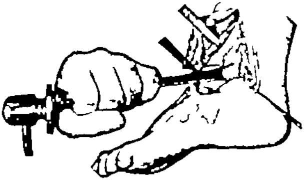
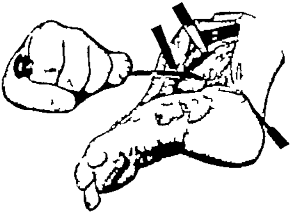


3 The joint between the lateral malleolus and the talus is excised with a straight osteotome, all the articular cartilage and a layer of subchondral bone being removed in thin strips. This leaves a narrow vertical space approximately ¼-inch wide between the malleolus and the talus.

Further excision of the joint

4 The front of the ankle joint is opened out by forcing the foot into equinus. A thin curved osteotome is used to resect the horizontal component of the joint between the tibia and the talus, thin sheets of cartilage and subchondral bone again being removed. The concavity of the tibial surface and the convexity of the talar surface are made to correspond. Any valgus or varus deformity of the foot is corrected at this stage by the appropriate resection of bone.

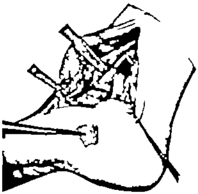


Medially the resection is carried into the base of the malleolus, but no attempt is made to excise this vertical part of the joint. Posteriorly the resection is carried back far enough to remove every visible piece of articular cartilage beyond this the osteotome is liable to damage the soft tissues at the back of the joint.

The extensive cancellous bone surfaces that have been obtained are deliberately made rough like the surface of a very coarse rasp with a narrow curved osteotome.

Preparation of bed for chips

5 A V-shaped transverse trough, opened forwards, is now cut out across the front of the joint for the reception of cancellous bone chips. In doing this any osteophytes on the lower tibia are removed and part of the neck of the talus is denuded of cortical bone. The trough is also roughened.



Insertion of bone chips

The lower end of the tibia about 1 inch above the joint is cleared of periosteum and a piece of cortex with cancellous bone attached, roughly the shape of the lateral malleolus, is raised. After some trimming this is forced back home between the malleolus and the talus.

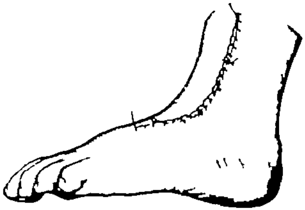
Bone chips of excellent quality are now dug out of the tibia. The foot is held in the desired
6 amount of equinus, usually not more than 1 inch for a man and 2 inches for a woman, and the chips are packed firmly into the trough prepared across the front of the joint.

The quality of bone in the lower tibia may be poor iliac chips are then used to pack the front of the joint.

Closure

7 The wound is closed in two layers without drainage. The tourniquet is released during the later stages of closure so as to reduce staining of the dressings by blood. A padded below-knee plaster cast is applied so as to maintain the correct amount of equinus.

Sometimes the ankle cannot be held firmly in a below-knee cast because the limb is shapeless or fat. An above-knee cast is then used with the knee held slightly bent it is moulded well round the foot and even round the toes.



POST-OPERATIVE CARE

A lateral radiograph is taken to check the amount of equinus, which may be adjusted at the time of application of the new cast.

A walking plaster is applied over stockinet after 2 weeks and is retained for a further 3 or 4 months of full weight-bearing after which radiographs are taken to confirm union. The return to normal gait is usually rapid.

Complications

A haematoma may develop particularly if the perforating artery has not been ligated.

Non-union is practically confined to cases in which a triple arthrodesis has previously been performed (*see* page 861)

[*The illustrations for this Chapter on Arthrodesis of the Ankle Joint were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S*]

References

Crawford Adams, J (1949). "Arthrodesis of the Ankle Joint Experiences with the Transfibular Approach." *J Bone Jt Surg.*, **30B** 500.

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REPAIR OF A RUPTURED TENDO ACHILLIS

K. L. NISSEN F.R.C.S.

Surgeon The Royal National Orthopaedic Hospital London

PRE-OPERATIVE

Sudden complete rupture of the tendo Achillis about an inch above its insertion is not uncommon in adults. The strain on the tendon at the moment of rupture is sometimes heavy but more often quite light. The extent of the rupture is not realized for several weeks until the swelling and bruising subside and a characteristic depressed contour becomes evident. The gap can then be palpated with ease.

The ruptured tendon makes some attempt at spontaneous repair and the gap becomes partly filled in with connective tissue. As a rule, however the lengthening of the tendon is too great and the function of the calf muscle can be regained only by a formal repair

Confirmation of diagnosis

Two simple tests for loss of function of the calf muscle help to confirm the diagnosis at this late stage. First the patient is asked to stand on the affected leg and lift the heel off the ground—he cannot do so Then the patient is asked to lie on a couch with both knees straight and the leg muscles relaxed Each foot is pushed upwards to the limit of passive dorsiflexion—the range is much greater on the side of the rupture.

Methods of repair

Occasionally the ends of the tendon can just be approximated and sutured with the foot in full equinus, but usually there is a persistent gap which needs reinforcement. Fascia lata can be used, and so can the plantaris tendon, which always remains intact alongside the site of rupture. Both these methods, however require a separate incision

In the technique described here, two strips are turned down from the broad upper part of the tendon and a second incision is avoided. The quality of this local suture material is excellent.

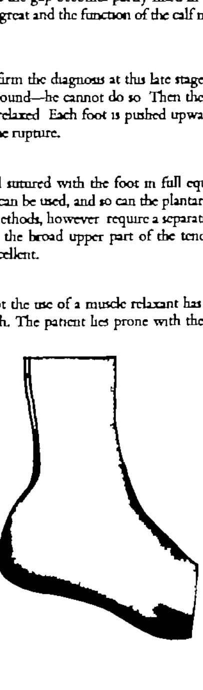
Anaesthesia and position of the patient

A general anaesthetic is induced. For once in the surgery of the foot the use of a muscle relaxant has a distinct advantage An exsanguinating tourniquet is applied to the lower thigh. The patient lies prone with the foot and ankle over the end of the table

THE OPERATION

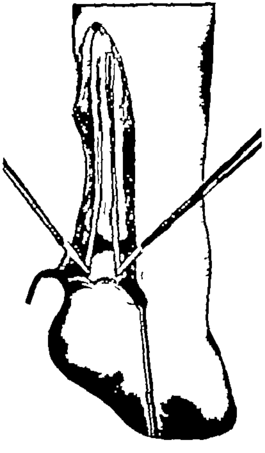
The incision and exposure

1 A straight incision is made down the middle of the tendo Achillis, from the musculo-tendinous junction above to the calcaneum below The superficial surface of both parts of the tendon is exposed and the gap between the rounded ends is cleared of loose connective tissue



Preparation of strips of tendon

2 The outlines of two long strips of tendon $\frac{1}{4}$ inch wide above narrowing to [illegible] inch below are made by shallow incisions following the grain of the fibres. Each strip is about [illegible] inch thick *and is turned down to within 1 inch of* the gap A few fibres of soleus muscle may need to be scraped off the upper end of each strip



Insertion of strips of tendon

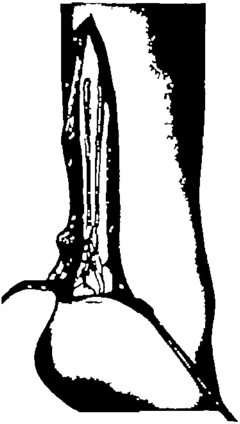
3 A transverse channel in the distal stump of tendon is cut near the calcaneum with a narrow scalpel. The ends of the strips are drawn through in opposite directions with the aid of Kocher's artery forceps.

Repair of the gap

4 The foot is placed in full equinus, and the ends of the two strips are gently drawn upwards across the narrowed gap to lie alongside the upper part of the tendon, where *they are fixed by fine silk sutures. The four* thicknesses of tendon suture are cobbled together with more fine silk. All the knots are cut short.

Closure and splintage

The foot is now allowed to relax from the position of full equinus. This facilitates suture of the skin by reducing the depth of the transverse furrows in the loose skin above the heel, a region which must be sutured with particular care in order to give good cover to the subcutaneous silk sutures. A below-knee padded plaster is applied with the foot in this position of relaxed equinus.



POST-OPERATIVE CARE AND COMPLICATIONS

The stitches are removed after 2 weeks. The patient is asked to reduce the equinus to a position of comfort, perhaps 20 degrees below the right angle, while a below-knee walking cast is applied over stockinet. The heel on the sound side needs to be raised about an inch to compensate for this amount of equinus.

All splintage is discarded after a further 6 weeks and normal walking is commenced, at first in shoes with a good height of heel to allow for the temporary limitation of dorsiflexion. In order to disperse the residual stiffness and any swelling, vigorous non-resisted active exercises are done regularly in the course of taking hot and cold contrast foot baths. Athletic activities may be resumed after a further 3 months.

Special complications

A knot of silk may give trouble and have to be removed.

A second rupture is practically unknown, likewise the calcified deposits so commonly seen in radiographs taken some time after a partial rupture of the tendon

[The illustrations for this Chapter on Repair of a Ruptured Tendo Achillis were prepared by Mr F Price from originals by Mr R. J Whitley F.R.P.S]

INDEX

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